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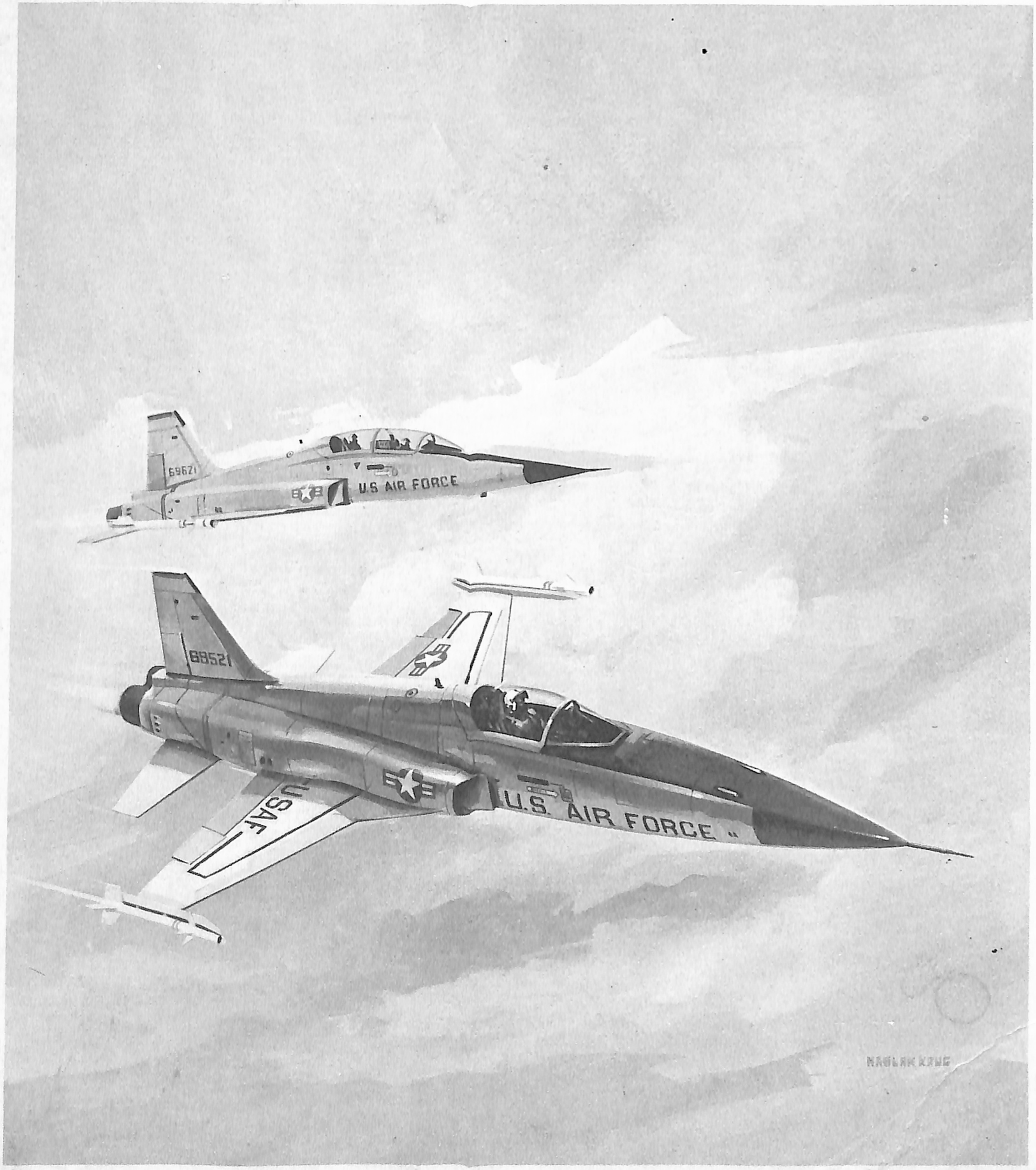
# NORTHROP

# F-5E/F

# TECHNICAL DESCRIPTION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# F-5E/F
# TECHNICAL DESCRIPTION

NORTHROP CORPORATION
Aircraft Division
3901 WEST BROADWAY, HAWTHORNE, CALIFORNIA 90250

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# INTRODUCTION

The Northrop F-5E/F Tiger II airplanes are the latest members of the F-5 series of supersonic tactical fighter aircraft designed for high performance, low initial cost, low operating cost and minimum logistics requirements. The airplane design philosophy has been proven by more than 1450 F-5 aircraft in operational service throughout the world.

The F-5E is a tactical fighter with design emphasis on the air superiority role but with excellent capability in the air-to-ground role. The airplane contains all of the basic elements of the F-5A plus:

- Two new 5000-pound thrust General Electric J85-GE-21 engines with a 22 percent thrust increase.
- Improved avionics capability for maximum mission effectiveness including an integrated fire control system with search and range track radar and lead computing sight.
- Airframe modifications for increased operational radii, improved maneuverability and shorter takeoff distance.

The F-5F is a fighter-trainer designed to carry out the training role but with essentially the same high capability as the F-5E in both the air superiority and air-to-ground roles. The F-5F airplane contains all of the basic features of the F-5E with the following differences.

The F-5F has two cockpits with radar indicator and all flight controls duplicated in the rear cockpit.

The F-5F has only one M-39 20mm gun with 140 rounds of ammunition instead of the two guns and 560 rounds in the F-5E.

This document provides a technical description of the F-5E/F airplanes, their flight and mission performance and air combat capability, handling qualities, F-5E/F systems descriptions and maintenance requirements.

Two appendices are presented at the end of this brochure. Appendix A presents descriptions of the various options which are available as additions to the basic F-5E/F configurations described in the body of the brochure. Appendix B presents Tropical Atmosphere performance for the F-5E airplane.

## STANDARD DELIVERY CONFIGURATION

Each F-5E aircraft is delivered with two 20mm M-39 guns, five external store pylons, two wingtip missile launchers, one 275-gallon centerline external fuel tank, and essential loose items. One container of additional loose items is shipped separately. The pylons are delivered in a nonjettisonable configuration; i.e., with standard nonexplosive attach bolts. Additional ordnance items and some selected airborne training equipment must be separately ordered from the U.S. Government

Each F-5F aircraft will be delivered in a similar fashion except that it has only one 20mm M-39 gun.

Both F-5E and F-5F aircraft contain provisions for additional or optional equipment. There are three categories of provisions, each of which is defined below:

Complete Provisions - This means that all supports, brackets, tubes and fittings, electrical wiring, hydraulic lines, etc., for a specific equipment item have been installed, that adequate weight and space allocations have been made for the installation without altering either the item or the aircraft, that the complete installation has been qualified, and that no additional parts other than standard attaching nuts, bolts, cotter pins, etc., are required.

Structural Provisions - This means that space is available and the primary aircraft structure is capable of accepting the installation. However, no brackets, electrical wiring, hydraulic lines, etc., have been provided.

Space Provisions - This means that space only has been allocated for the installation. No brackets, bolt holes, electrical wiring, hydraulic lines, etc., are furnished and an adequate attaching structure is not necessarily provided.

# SECTION 1

# GENERAL DESCRIPTION

# SECTION 1

# GENERAL DESCRIPTION

The F-5E/F airplanes are the latest in the F-5 series of high performance tactical fighters. The F-5E is a single-place, supersonic fighter aircraft powered by twin J85-GE-21 turbojet engines of 5000 pounds thrust each. Externally, the F-5E differs from the F-5A principally in the design of the engine air inlet ducts, the dorsal area aft of the cockpit, and the wing leading edge extension. The air induction system inlets are resized to accommodate the higher airflow requirements of the higher-thrust J85-GE-21 engines. The center fuselage, lengthened 15 inches, is modified to provide increased internal fuel which, with an increase in size of the external fuel tanks from 150 gallons to 275 gallons, significantly extends mission radius capability. The wing leading edge extension is enlarged and the wing flaps redesigned for use as maneuvering flaps to increase aerodynamic load factor capability and thereby improve the maneuvering performance of the aircraft The general planform of the F-5E/F wing, with the exception of the leading edge extension, is the same as the F-5A/B; however, the basic wing area has been increased from 170 to 186 square feet by extending the wings outboard 8.5 inches from the aircraft centerline.

The F-5F is a two-place derivative of the F-5E tactical fighter that retains the combat capability and weapon delivery accuracy of the F-5E and provides the advantages of a two-place trainer. The design philosophy of the F-5F has combined the flight performance and maneuverability improvements, the improved avionics package, and the fire control system of the F-5E with the proven F-5B two-place cockpit systems to produce a truly versatile aircraft.

Mission effectiveness of the F-5E/F airplanes has been improved by the addition of an integrated fire control system for the air-to-air use of the M-39 guns and AIM-9 missiles. This system employs a search and range track radar and a lead-computing sight with missile in-range computation capability. Navigation capability has been supplemented by the addition of a UHF ADF system and an X-band Transponder. The UHF command radio, IFF/SIF system and the attitude and heading reference system employ solid state technology resulting in high reliability and low maintenance. The avionics arrangement allows space for additional equipment to provide increased mission capability.

Takeoff gross weights for the F-5E range from 15,292 pounds to 24,018 pounds (not including growth capability *). The F-5E sea level takeoff distances vary between 1800 feet and 5100 feet at these weights. The corresponding F-5F weights are 15,656 lb to 24,382 lb and F-5F sea level takeoff distances vary from 2150 ft to 6050 ft. Flight performance characteristics include an F-5E sea level climb rate of 33,500 feet per minute, a combat ceiling of 52,500 feet, and a maximum speed of Mach 1.6. The radius of action of many missions for the F-5E is considerably greater than competitive aircraft of much larger size. Mission performance includes a combat air patrol mission radius of 680 nautical miles and an interdiction mission radius of 510 nautical miles both with (3) 275-gallon tanks. Minimum landing distance of 2200 feet is attained with a touchdown speed of 121 knots with drag chute deployment for the intercept mission landing weight. The wide track landing gear and low-speed control provide excellent landing characteristics in 90-degree crosswinds up to 40 knots. Refer to Section 2 for complete and detailed F-5E/F performance. F-5F performance numbers are comparable to the F-5E in all areas.

The F-5E/F aircraft can carry a wide selection of external loads for air-to-air combat, close support, interdiction and training missions. The AIM-9 missiles and two 20mm M-39 guns with 560 rounds of ammunition (one gun and 140 rounds in the F-5F) provide effective air-to-air firepower. The aircraft incorporate such operational features as jettisonable centerline and optional inboard pylon fuel tanks, jettisonable pylons, single-point refueling for internal and external tanks, two-position nose gear, and provisions for nonjettisonable tip tanks.

Fundamental design safety features of the F-5E/F include twin engines, dual fuel systems, dual primary systems (electrical and hydraulic) and controlled cockpit environment.

The full power flight control system is powered by dual hydraulic systems. Each primary flight control surface is operated by dual-powered actuators. If either hydraulic system fails, the remaining system provides adequate power to the flight controls. Two separate engine-driven, 13/15 KVA alternating-current generators power the electrical systems. An automatic transfer function is provided so that both systems may be supplied by one generator in the event the other fails.

---

* Unless otherwise noted, the terms growth or growth capability as used in this document are defined as encompassing those stores for which the airplane has complete provisions, hard points, racks, wiring, plumbing, etc., but which require clearance based on analyses and test qualification. F-5E maximum-weight, growth configuration with AIM-9 missiles is 25,124 pounds. A given loading is transferred from the growth to the qualified category when contractual coverage is received and the effort to clear the configuration has been initiated.

The forward cockpit of the F-5F contains the F-5E lead computing optical sight, fire control radar indicator and controls, all of the instruments and controls of the F-5E, plus functions required for coordination with the rear cockpit. The rear cockpit contains all instruments necessary for flight, systems monitoring, and override functions. The rear cockpit is also equipped with a radar indicator and controls. A transfer switch allows the rear cockpit pilot to monitor or control the radar and the rear cockpit radar indicator is equipped with fire control system status lights to display modes selected by the front cockpit pilot.

General dimensional data are presented in Table 1-1 and in the three-view drawings in Figures 1-1 and 1-2.

## TABLE 1-1. F-5E/F GENERAL DATA

| SECTION | | |
|---|---|---|
| WING | AREA TOTAL (INCLUDING AILERONS, FLAPS, 57.5 FT$^2$ OF FUSELAGE, AND EXPOSED LEADING EDGE EXTENSION) | 194.42 FT$^2$ |
| | AREA BASIC (REFERENCE) (INCLUDING AILERONS, FLAPS, 57.5 FT$^2$ OF FUSELAGE BUT EXCLUDING LEADING EDGE EXTENSION) | 186.25 FT$^2$ |
| | TAPER RATIO – BASIC WING | 0.19 |
| | ASPECT RATIO – BASIC WING (SPAN: 26 FT, 8 IN; AREA: 186.25 FT$^2$) | 3.82 |
| | SWEEPBACK AT 25% CHORD | 24° |
| | AIRFOIL SECTION | NACA 65A-004.8 MODIFIED |
| | FLAP AREA – TRAILING EDGE (TOTAL) | 21 FT$^2$ |
| | FLAP AREA – LEADING EDGE (TOTAL) | 12.30 FT$^2$ |
| | FLAP MOVEMENT: | |
| | LEADING EDGE (ROOT) | 24° DOWN |
| | TRAILING EDGE | 20° DOWN |
| | AILERON AREA – AFT OF HINGE – PER AILERON | 4.62 FT$^2$ |
| | AILERON MOVEMENT: | |
| | GEAR DOWN | 35° UP, 25° DOWN |
| | GEAR UP | 18.5° UP, 14° DOWN |
| HORIZONTAL TAIL | AREA TOTAL (INCLUDING 25.97 FT$^2$ OF FUSELAGE) | 59.00 FT$^2$ |
| | AREA EXPOSED | 33.03 FT$^2$ |
| | TAPER RATIO (EXPOSED) | 0.33 |
| | ASPECT RATIO (EXPOSED) | 2.88 |
| | SWEEPBACK AT 25% CHORD | 25° |
| | AIRFOIL SECTION | NACA 65A-004 |
| | SURFACE MOVEMENT TRAILING EDGE | F-5E 17° UP, 5° DOWN<br>F-5F 20° UP, |
| VERTICAL TAIL | AREA EXPOSED | 41.42 FT$^2$ |
| | TAPER RATIO (EXPOSED) | 0.25 |
| | ASPECT RATIO (EXPOSED) | 1.22 |
| | SWEEPBACK AT 25% CHORD | 25° |
| | AIRFOIL SECTION | NACA 65A-004 MODIFIED |
| RUDDER | AREA – AFT OF HINGE | 6.10 FT$^2$ |
| | MOVEMENT (MAXIMUM) | 30° RIGHT, 30° LEFT |
| SPEED BRAKE | AREA TOTAL | 6.42 FT$^2$ |
| | SURFACE POSITION (MAXIMUM DOWN) | 45° (RELATIVE TO HRL) |
| USABLE FUEL | INTERNAL VOLUME (AT 6.5 LB/GAL) | F-5E 4400 LB (677 GAL)<br>F-5F 4390 LB (675.5 GAL) |
| POWER PLANT | TURBOJETS WITH AFTERBURNERS | (2) J85-GE-21 |
| LANDING GEAR | MAIN GEAR TIRE SIZE | 24 x 8.0-13 |
| | NOSE GEAR TIRE SIZE | 18 x 6.5-8 |
| WEIGHTS | EMPTY | 9,425 LB (E) 10,100 LB (F) |
| | T.O. WEIGHT (LAUNCHER RAILS) | 15,292 LB (E) 15,656 LB (F) |
| | (AIM-9 CONFIGURATION) | 15,632 LB (E) 15,996 LB (F) |
| | (MAXIMUM GROSS WEIGHT)* | 24,018 LB (E) 24,382 LB (F) |
| | WEIGHTS INCLUDE FULL AMMO & CREW | |

*(2) AIM-9J, (3) 275-GAL TANKS + (2) BLU-27/B(F)

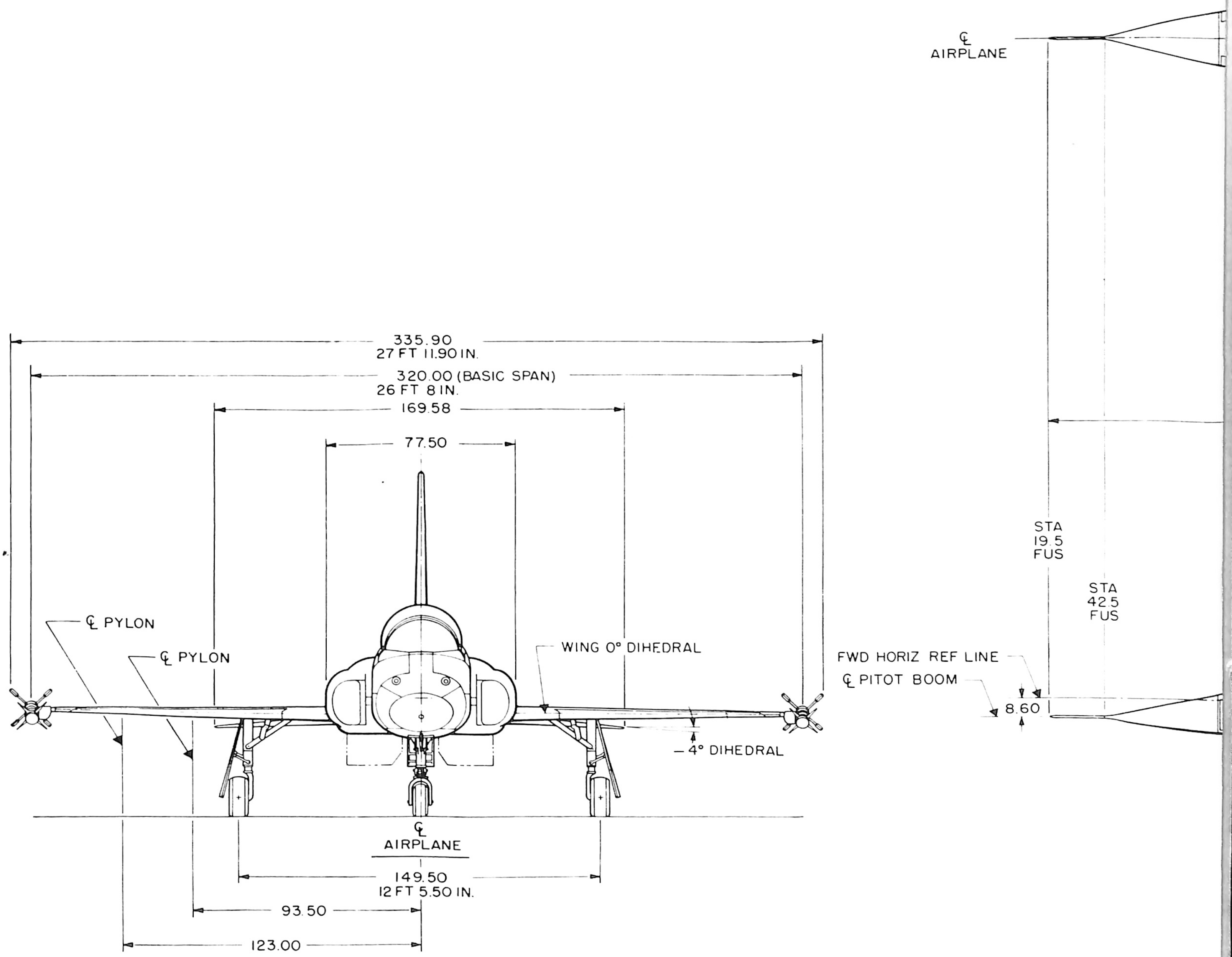

℄
AIRPLANE
335.90
27 FT 11.90 IN.
320.00 (BASIC SPAN)
26 FT 8 IN.
169.58
77.50
STA
19.5
FUS
STA
42.5
FUS
℄ PYLON
℄ PYLON
WING 0° DIHEDRAL
FWD HORIZ REF LINE
℄ PITOT BOOM
8.60
– 4° DIHEDRAL
℄
AIRPLANE
149.50
12 FT 5.50 IN.
93.50
123.00

FIGURE 1-1. F-5E THREE-VIEW DRAWING

# SECTION 2

# PERFORMANCE

ALL PERFORMANCE IS BASED ON MIL SPEC MIL-C-5011A EXCEPT AS MODIFIED TO INCLUDE OPERATIONAL EXPERIENCE GAINED FROM DEPLOYMENT OF F-5A/B, C/D, CF-5A/D and NF-5A/B MODELS.

# SECTION 2

## PERFORMANCE

Performance values presented in this section are estimated from predicted J85-GE-21 engine data and from drag data derived from F-5E and F-5F wind tunnel tests. Incremental drag due to changes in configuration was estimated and added to the F-5E drag to obtain the F-5F drag. These performance values will be changed to reflect flight test data when Category II test results have been fully analyzed.

Basic F-5E/F performance data are presented in Table 2-1 and mission performance in Table 2-2. Weights used in this section are presented in Table 2-6 for JP-4 fuel and Table 2-9 for Jet A-1 fuel. Except as otherwise noted, all performance values are for standard atmosphere and full ammunition. All F-5F performance except the ferry missions is with a crew of two. F-5F training missions are computed with 50 rounds of ammunition as per normal training practice. All other F-5F missions except the ferry mission are computed with 140 rounds of ammunition. Neither ammunition nor links are carried on ferry missions for either aircraft.

F-5E standard day performance with both JP-4 fuel and Jet A-1 fuel is presented in this section. Performance with Jet A-1 fuel is presented on pages 2-42 and 2-43. F-5E Tropical Atmosphere performance with JP-4 fuel is presented in Appendix B.

TABLE 2-1. PERFORMANCE SUMMARY (LAUNCHER RAIL CONFIGURATION)

| | F-5E | F-5F |
|---|---|---|
| TAKEOFF GROSS WEIGHT – POUNDS | 15,292 | 15,656 |
| TAKEOFF DISTANCE (SEA LEVEL) – FEET | 1,800 | 2,150 |
| TAKEOFF SPEED (SEA LEVEL) – KTAS | 144 | 153 |
| TIME TO CLIMB (BRAKE RELEASE TO 40,000 FEET) – MINUTES | 3.3 | 3.4 |
| RATE OF CLIMB (SEA LEVEL) – FEET PER MINUTE | 33,500* | 31,700** |
| MAXIMUM SPEED (36,089 FEET) – MACH NUMBER | 1.6* | 1.54** |
| MAXIMUM SPEED (SEA LEVEL) – MACH NUMBER | 1.02* | 1.02** |
| COMBAT CEILING – FEET | 52,500* | 51,300** |
| LANDING WEIGHT (LANDING FUEL RESERVES; AMMUNITION EXPENDED) – POUNDS | 11,192 | 11,778 |
| LANDING DISTANCE (WITH DRAG CHUTE SEA LEVEL) – FEET | 2,200 | 2,300 |
| LANDING SPEED (SEA LEVEL) – KTAS | 121 | 130 |

*WEIGHT: F-5E 13,092 POUNDS WITH 50 PERCENT FUEL AND LAUNCHER RAILS.
**WEIGHT: F-5F 13,456 POUNDS WITH 50 PERCENT FUEL AND LAUNCHER RAILS.

## TAKEOFF AND LANDING DISTANCES

Takeoff ground distances and distances to clear a fifty-foot obstacle are presented for sea level takeoffs as a function of aircraft weight for the F-5E in Figure 2-1 and F-5F in Figure 2-2. The takeoff ground-run for the F-5E varies from 1800 feet for the wingtip launcher rail configuration at 15,292 pounds, to 5100 feet at maximum-weight configuration at 24,018 pounds with AIM-9 missiles. The distances for the F-5F vary from 2150 feet at 15,656 pounds to 6050 feet for the maximum-weight F-5F configuration with AIM-9 missiles at 24,382 pounds.

Landing distances for sea level are presented for the F-5E in Figure 2-3 and the F-5F in Figure 2-4 both with and without the drag chute. Maximum braking (friction coefficient 0.300) is used. The F-5E landing ground roll with drag chute is 2200 feet for the intercept mission landing weight of 11,192 pounds.

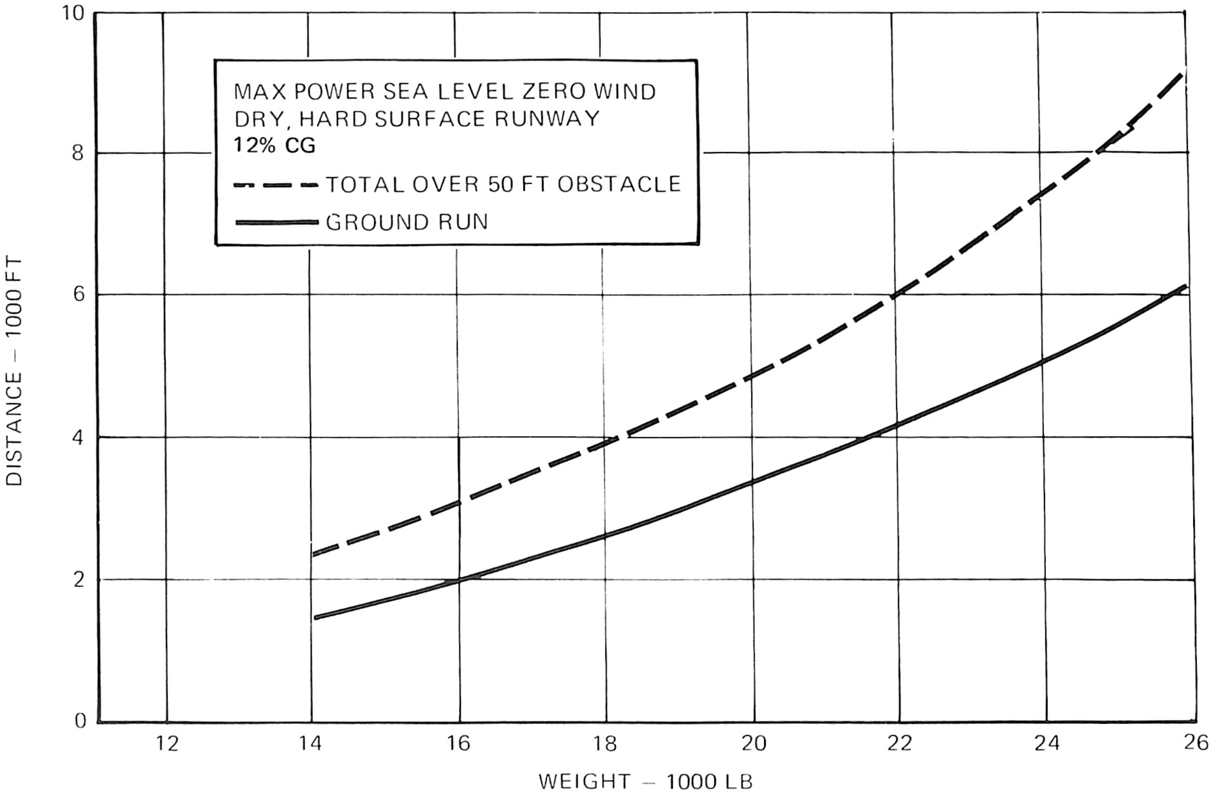


FIGURE 2-1. F-5E TAKEOFF DISTANCE (TWO-POSITION NOSE GEAR)

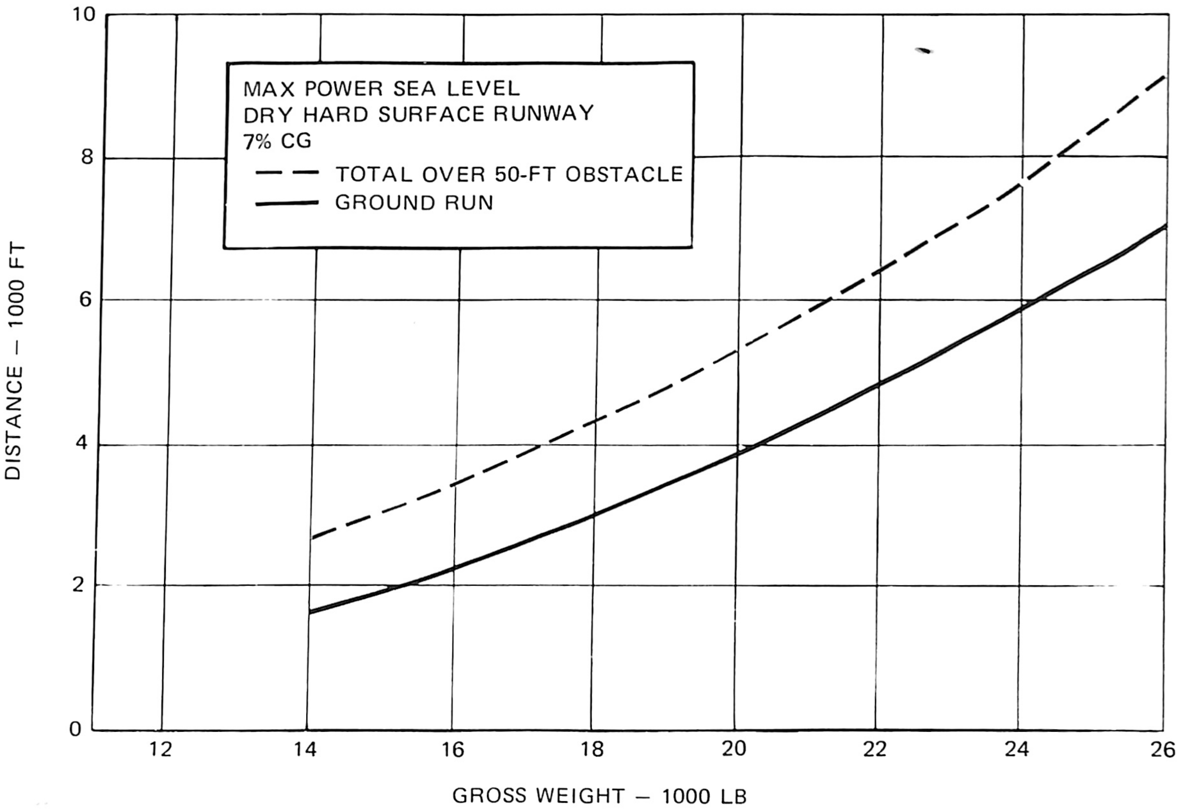


FIGURE 2-2. F-5F TAKEOFF DISTANCE (TWO-POSITION NOSE GEAR)

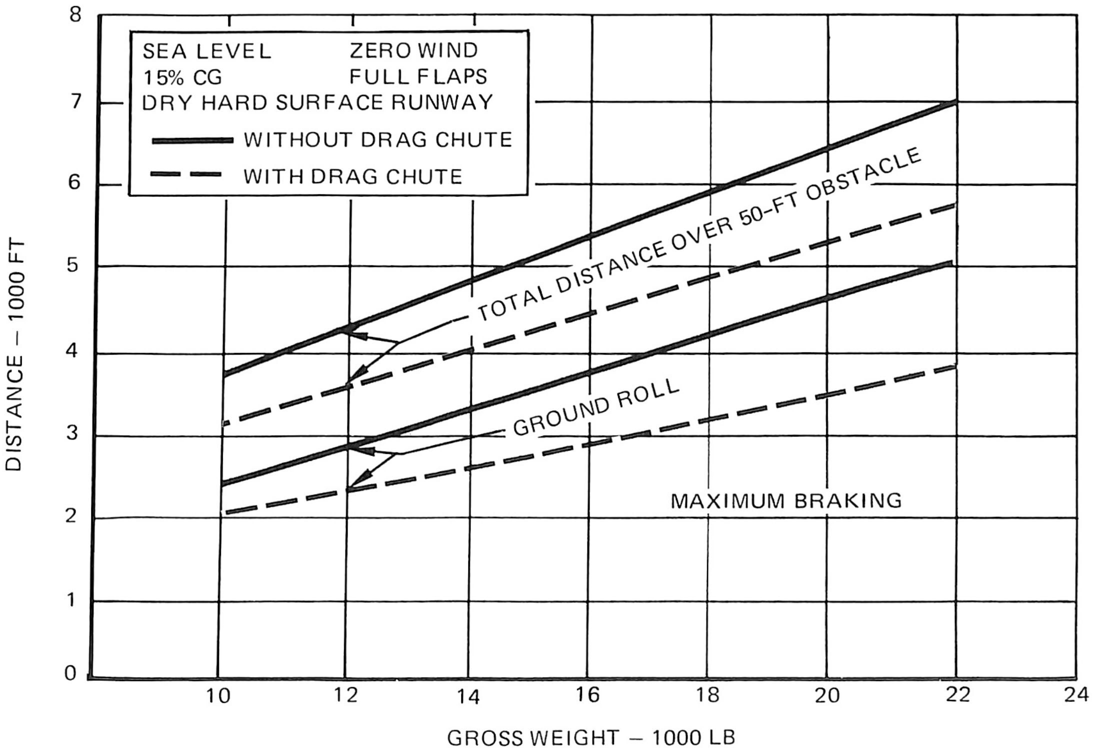


FIGURE 2-3. F-5E LANDING PERFORMANCE

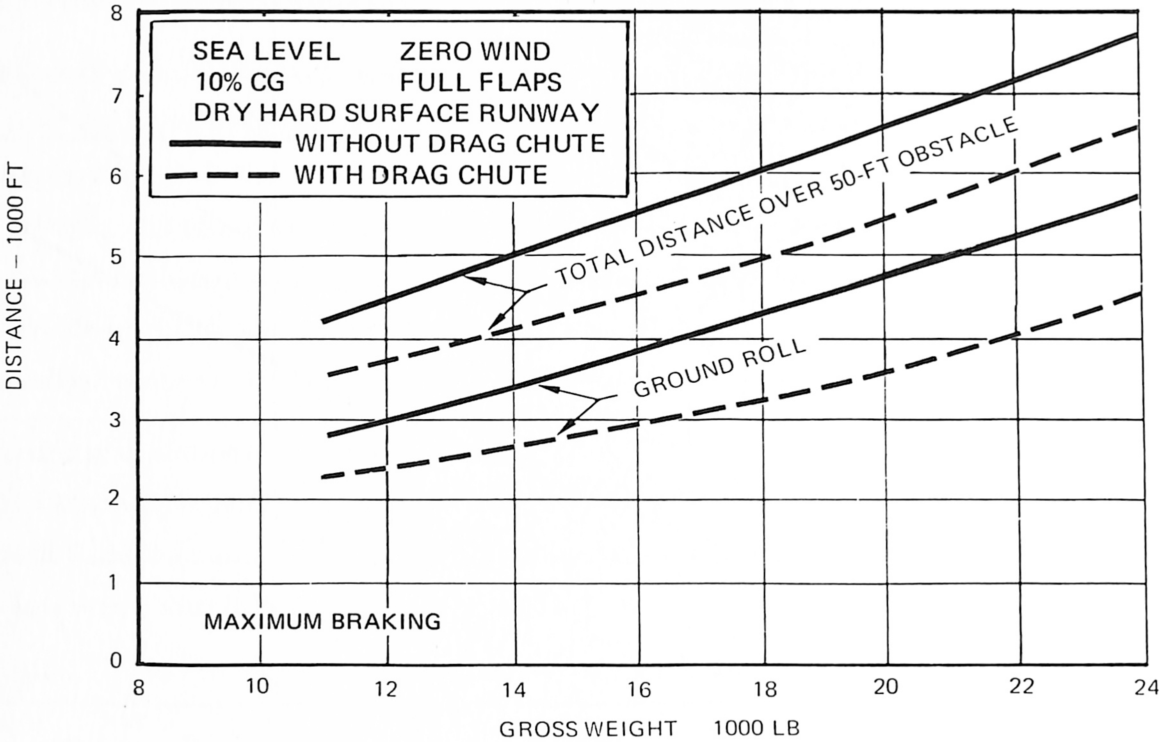


FIGURE 2-4. F-5F LANDING PERFORMANCE

## CLIMB AND MACH SUMMARIES

The climb capability of the F-5E aircraft, equipped with AIM-9 wingtip missiles and with launcher-rails-only, is presented in Figure 2-5 and the F-5F in Figure 2-6. The time-to-climb curves are calculated for airplane weights that are reduced as fuel is used from the start of takeoff and time begins at brake release. The rate-of-climb curves are computed for a constant 50 percent fuel combat weight with full ammunition.

Maximum and military power level flight operational envelopes for the AIM-9 missile configuration and the launcher-rail-only configuration, at 50 percent fuel combat weight with full ammunition are presented for the F-5E in Figure 2-7 and for the F-5F in Figure 2-8.

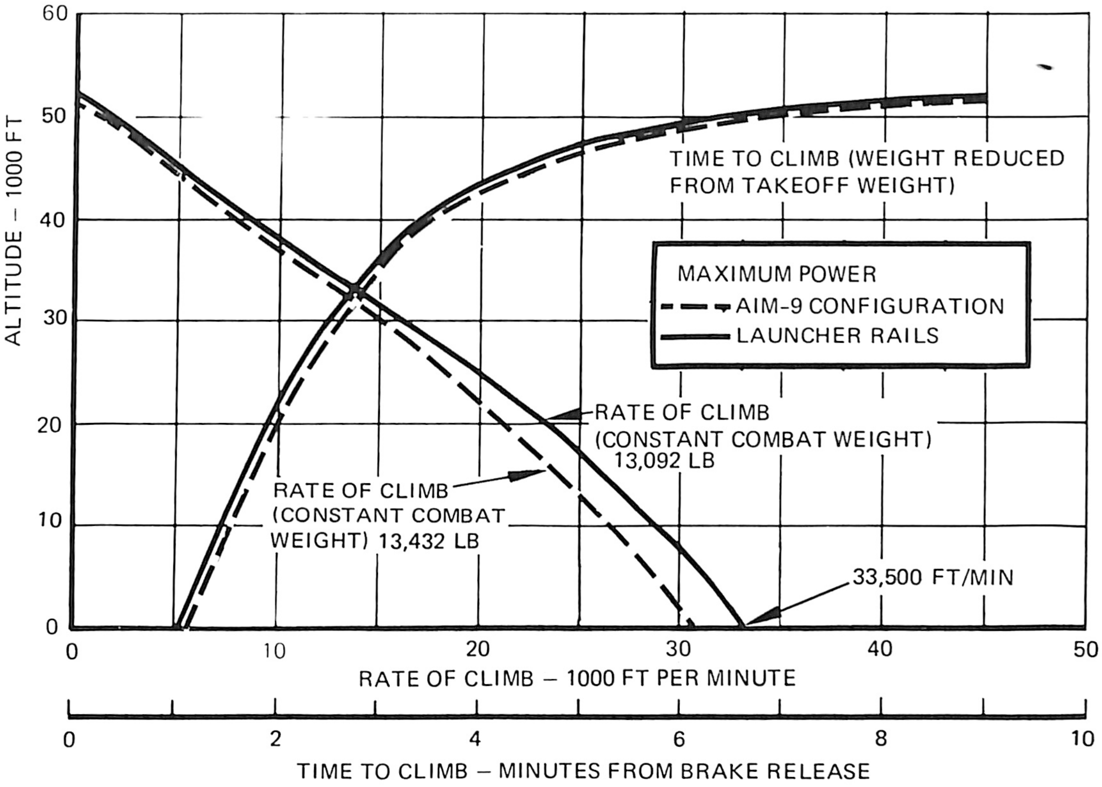


FIGURE 2-5. F-5E CLIMB PERFORMANCE

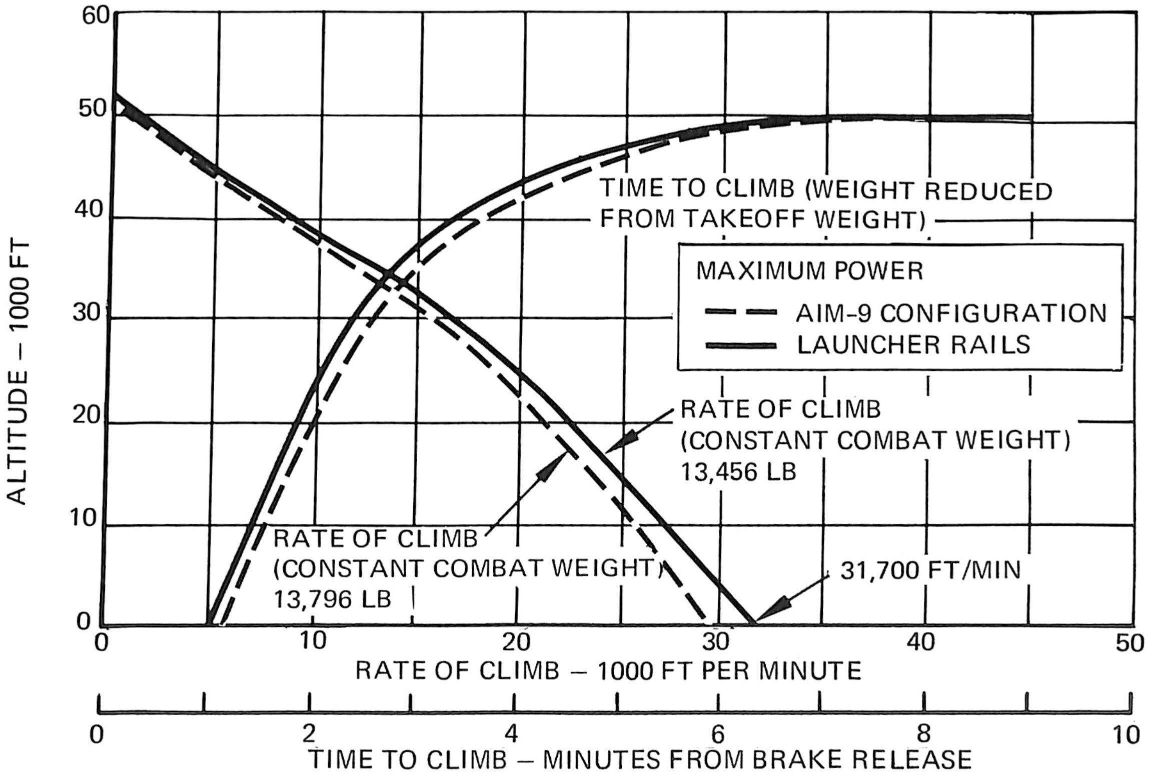


FIGURE 2-6. F-5F CLIMB PERFORMANCE

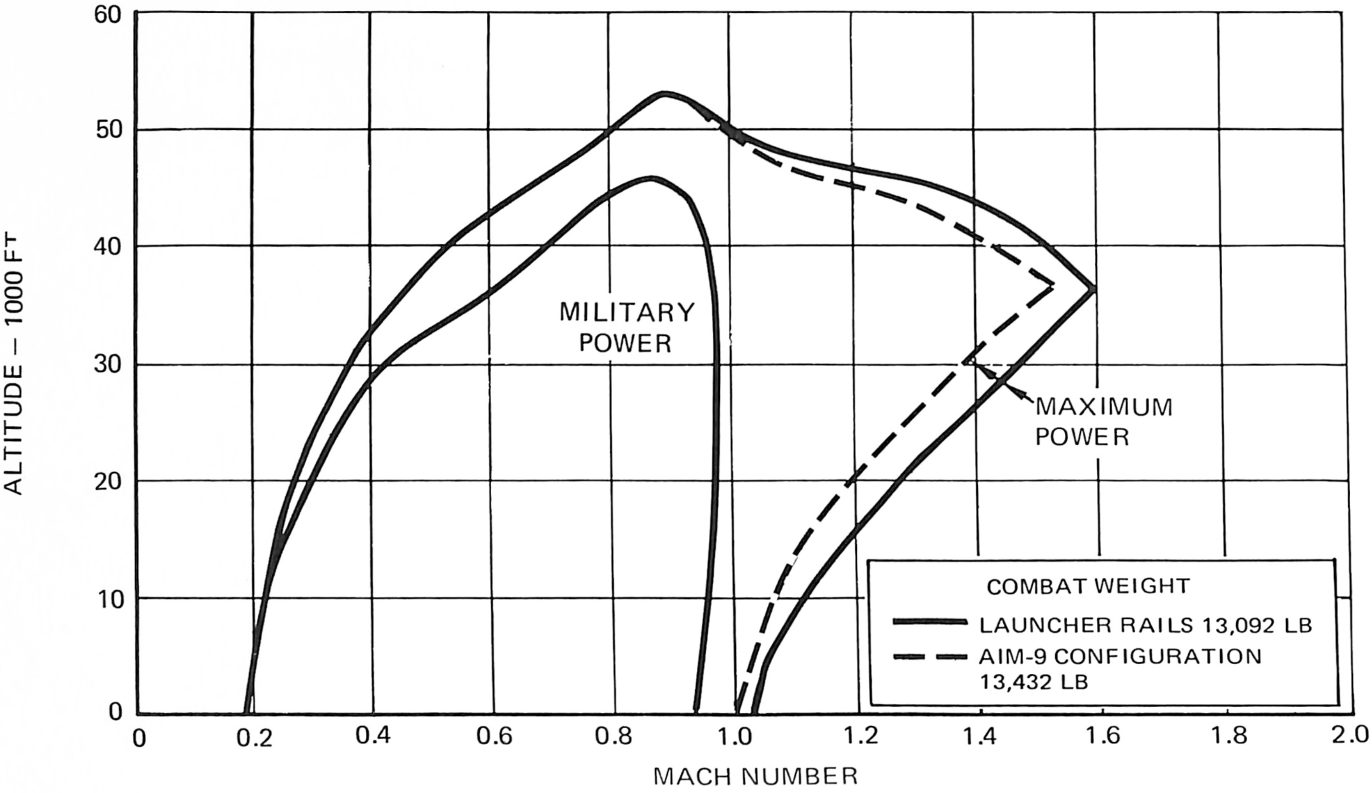


FIGURE 2-7. F-5E MACH SUMMARY

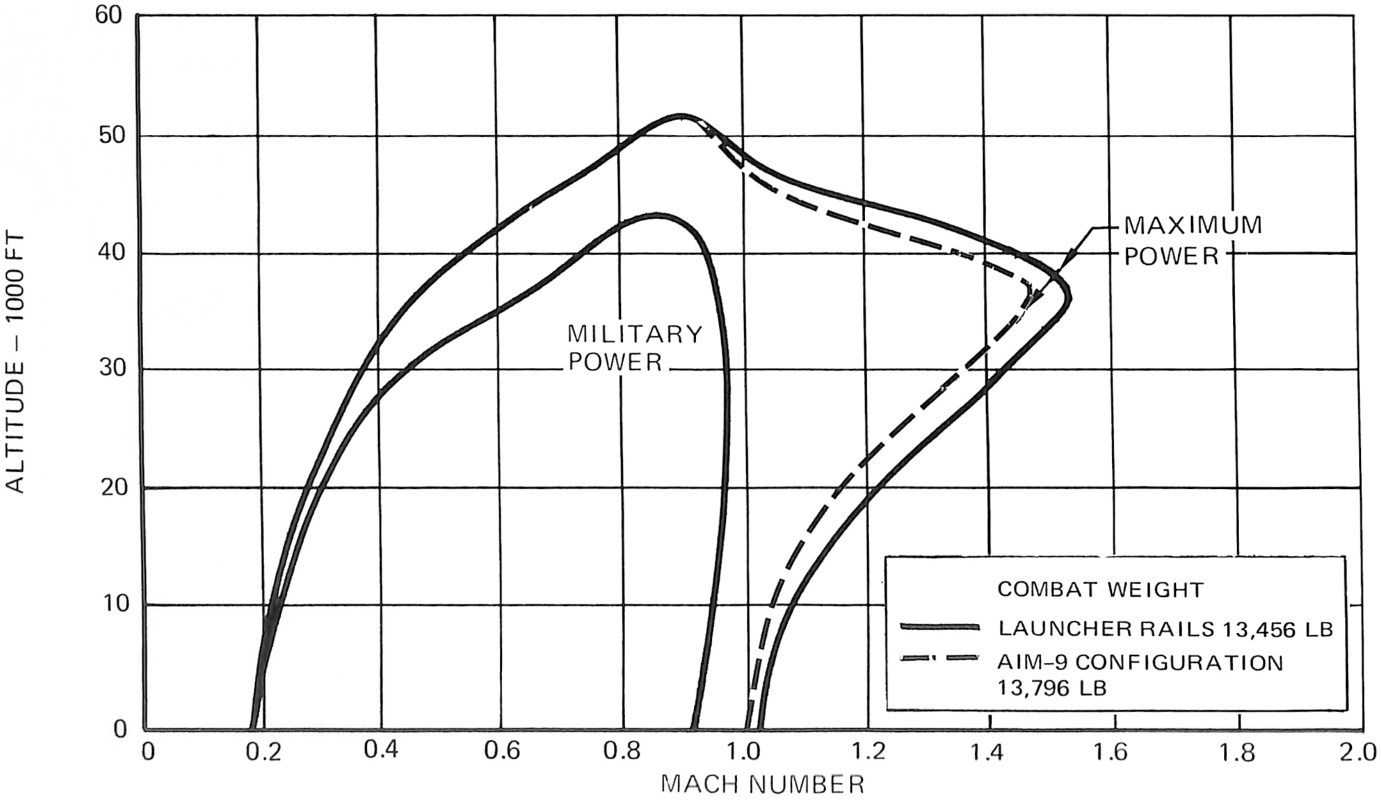


FIGURE 2-8. F-5F MACH SUMMARY

## MISSION PERFORMANCE

Data presented in the mission performance summary, Table 2-2, were computed using the mission rules presented in each of the mission profile illustrations, Figures 2-11 thru 2-43, and the ferry mission rules on Figure 2-44 together with airplane and stores weights derived from Table 2-7.

### TABLE 2-2. MISSION PERFORMANCE SUMMARY

| MISSION | | F-5E | F-5F |
|---|---|---|---|
| COMBAT AIR PATROL (2) AIM-9 MISSILES | | | |
| (1) 275-GAL PYLON TANK | RADIUS | 415 N MI | 375 N MI |
| (3) 275-GAL PYLON TANKS | RADIUS | 680 N MI | 600 N MI |
| SUPERSONIC AREA INTERCEPT WITH 275-GAL ℄ TANK | RADIUS | 190 N MI | 185 N MI |
| POINT INTERCEPT (WITH (2) AIM-9'S) – TIME TO 40,000 FEET FROM BRAKE RELEASE | TIME | 3.5 MINUTES | 3.6 MINUTES |
| INTERDICTION (HI-LO-HI) | | | |
| (2) MK 82 + (3) 275-GAL PYLON TANKS RETAINED | RADIUS | 540 N MI | 505 N MI |
| INTERDICTION (LO-LO-HI)* | | | |
| (2) MK 82 + (3) 275-GAL PYLON TANKS RETAINED | RADIUS | 460 N MI | 435 N MI |
| INTERDICTION (LO-LO-LO)* | | | |
| MAXIMUM FUEL (2) MK 82 + (3) 275-GAL PYLON TANKS RETAINED | RADIUS | 380 N MI | 370 N MI |
| MAXIMUM BOMB LOAD | RADIUS | 150 N MI | 140 N MI |
| MAXIMUM BOMB LOAD (GROWTH SINGLE BOMBS) | RADIUS | 140 N MI | 130 N MI |
| FERRY WITH LAUNCHER RAILS | | | |
| 275-GAL ℄ PYLON TANK DROPPED | RANGE | 1395 N MI | 1310 N MI** |
| 275-GAL ℄ PYLON TANK RETAINED | RANGE | 1315 N MI | 1240 N MI** |
| FERRY WITH AIM-9 MISSILES | | | |
| (3) 275-GAL PYLON TANKS DROPPED | RANGE | 1755 N MI | 1650 N MI** |
| (3) 275-GAL PYLON TANKS RETAINED | RANGE | 1555 N MI | 1455 N MI** |

*LOW ALTITUDE CRUISE ON LO-LO-LO AND LO-LO-HI MISSIONS AT SEA LEVEL; COMBAT IS ALSO AT SEA LEVEL

**ONE CREW IN F-5F

Takeoff weights for various mission configurations are presented for the F-5E in Table 2-7 and for the F-5F in Table 2-8. Fuel and ordnance weights are listed in these tables.

The mission rules do not allow a distance credit for letdown from cruise altitude. If allowance were given for letdown, approximately 20 nautical miles for LO-LO-HI and 40 nautical miles for HI-LO-HI could be added to the mission radii.

The F-5E/F carries 275-gallon tanks on the centerline and, as an option, on the inboard wing pylons. Performance data with one (1), two (2) and three (3) pylon tanks are included in this section. Missions and performance for the F-5E with multiple store loadings on Multiple Ejection Racks (MERs) and Triple Ejection Racks (TERs) are also presented. TER rack data show growth capability.

Refer to Figure 4-86 Armament Subsection of Section 4, for qualified stores and growth stores. The terms growth and growth capability are defined to mean those stores for which the airplane has complete provisions, hard points, racks, wiring, plumbing, etc., but which require clearance based on flight test qualification. Qualified stores have either completed the clearance procedure or are in process of being cleared.

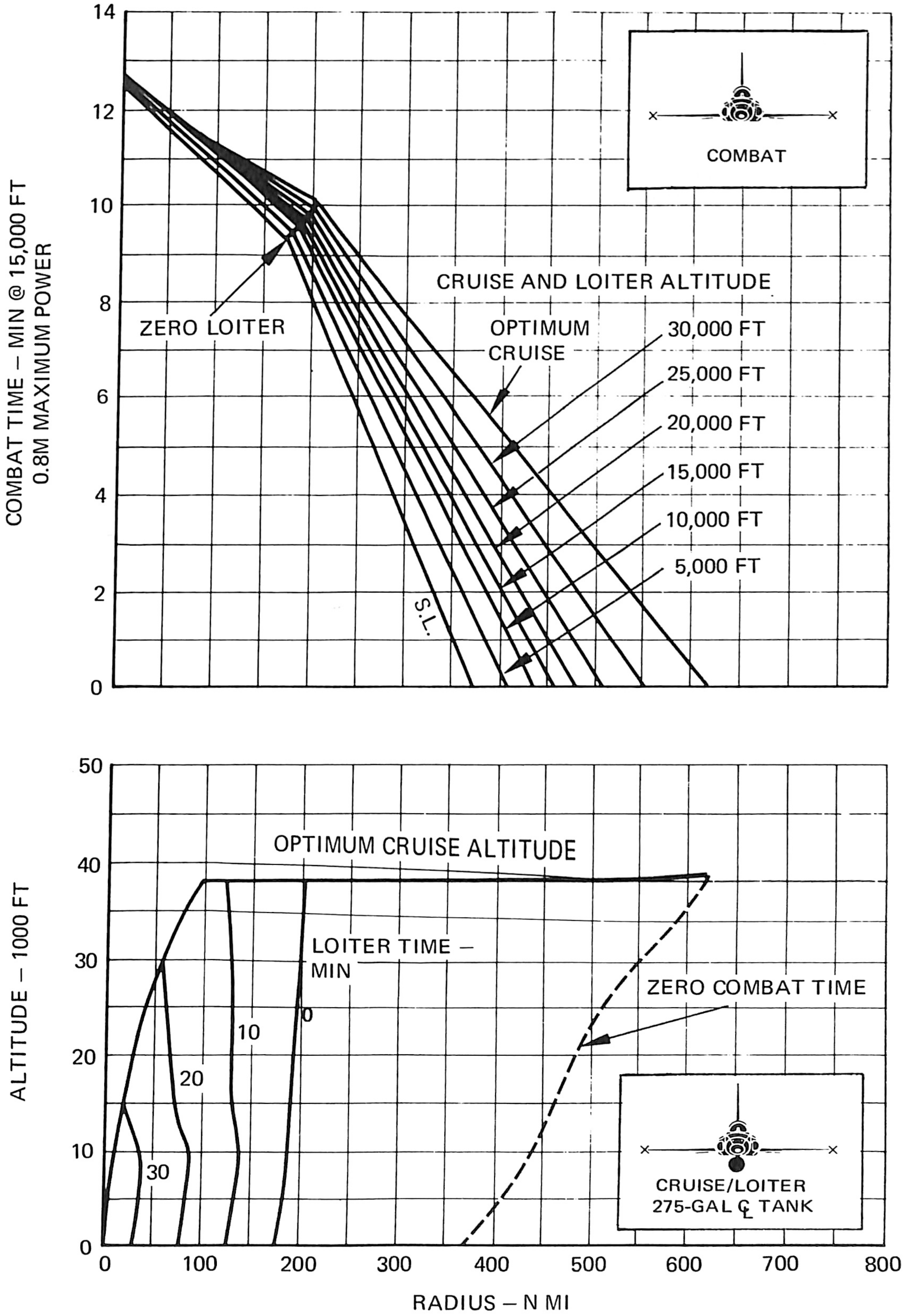
### Combat Air Patrol Missions

Figures 2-9 and 2-10 present F-5E combat air patrol loiter tradeoffs and combat times from sea level to optimum cruise altitude. The takeoff configuration for Figure 2-9 is two AIM-9 missiles and a single centerline 275-gallon tank. For Figure 2-10 the takeoff configuration is two AIM-9 wingtip missiles plus three 275-gallon pylon tanks. Figures 2-9 and 2-10 illustrate how far from base a contact with an intruder aircraft can be made by cruising out at various altitudes, loitering on external fuel, combating at maximum power, and returning to base at cruise altitude noted. For example, in Figure 2-10, if cruise-out is at 20,000 feet to a point 500 nautical miles away, the F-5E can loiter 20 minutes at 20,000 feet on external fuel then combat 5.2 minutes at 15,000 feet starting with full internal fuel, and return to base. At extended radii, beyond the zero-loiter boundary, it is not possible to start combat with full internal fuel. Tanks and pylons are jettisoned at the start of combat. In an actual mission where there is no enemy fighter engagement, tanks would be carried home.

Figures 2-11 and 2-12 present typical F-5E and F-5F combat air patrol mission profiles with the mission rules applicable for the extended radius mission.

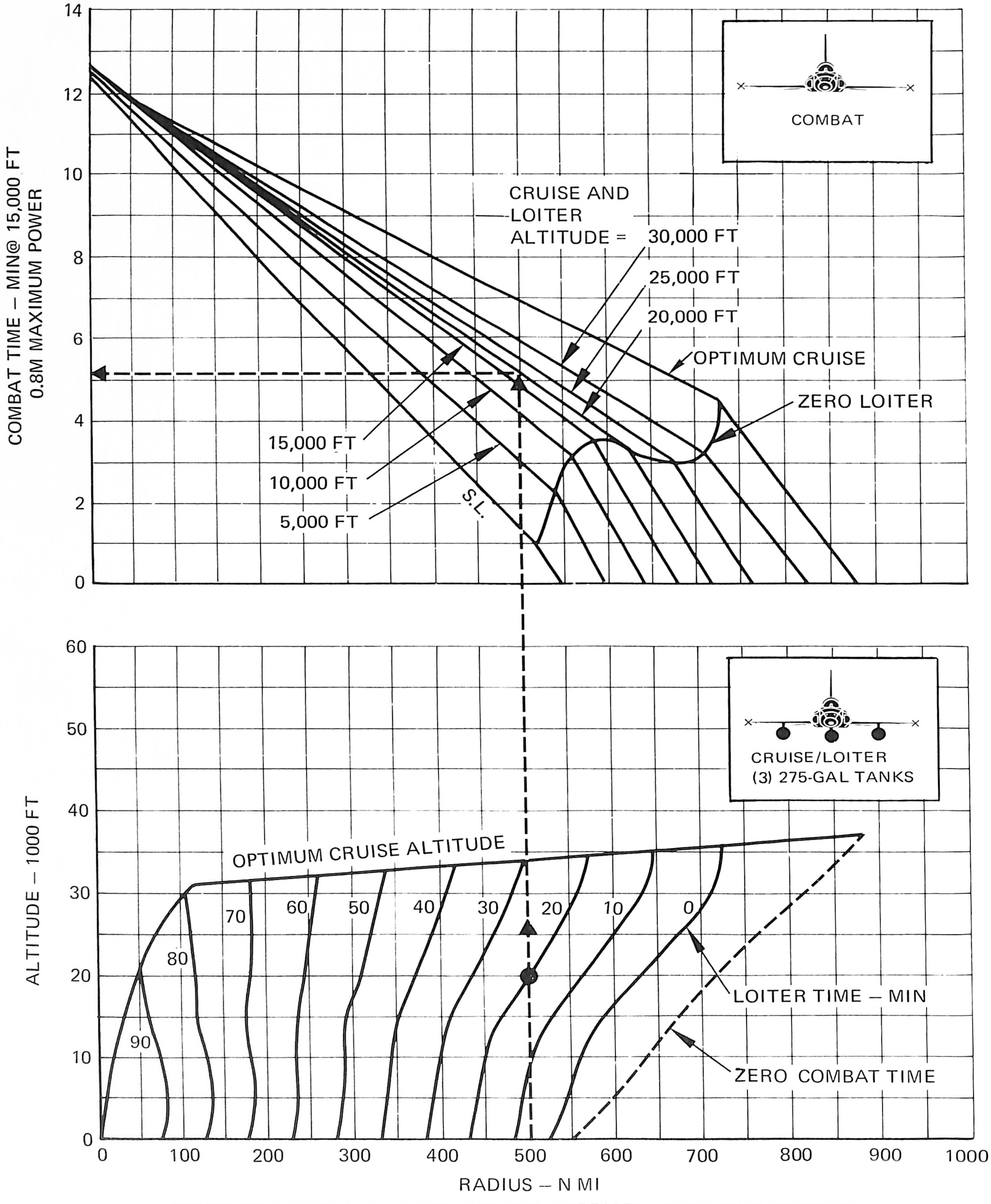
### Subsonic Area Intercept Mission

Figures 2-13 and 2-14 present the F-5E and F-5F air-to-air subsonic high altitude area intercept capabilities when operating at normal cruise speeds. Missions are shown with AIM-9 missiles only and with one and three pylon tanks. Wing tanks are dropped when empty. Centerline tank and all pylons are dropped when the centerline tank is empty.



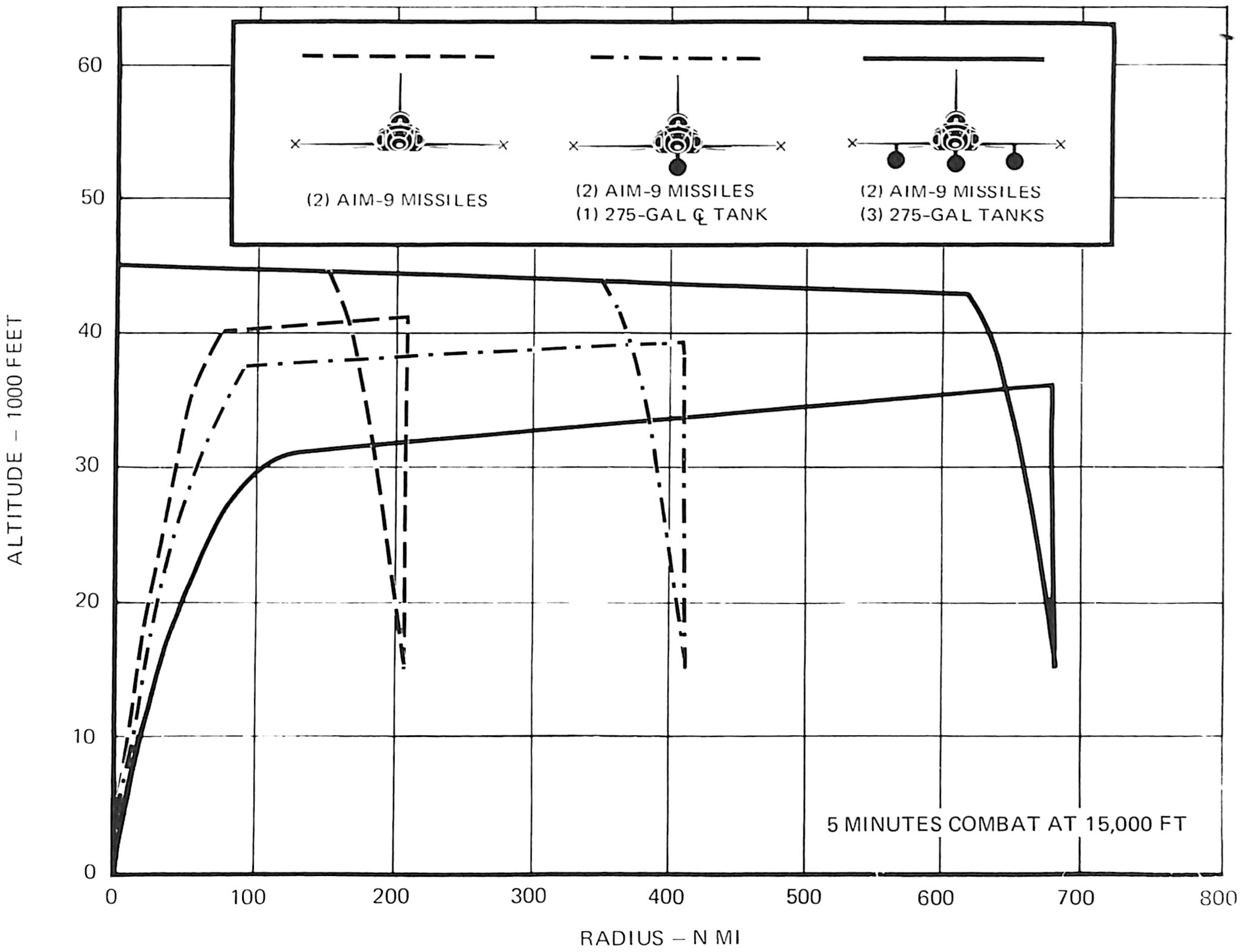
EXCESS COMBAT TIME CAN BE TRADED FOR INCREASED LOITER TIME AT THE RATE OF 8.5 MINUTES OF LOITER AT OPTIMUM CRUISE ALTITUDE TO ONE MINUTE OF COMBAT.

FIGURE 2-9. F--5E COMBAT AIR PATROL COMBAT AND LOITER TIME WITH 275-GAL ℄ TANK



EXCESS COMBAT TIME CAN BE TRADED FOR INCREASED LOITER TIME AT THE RATIO OF 6.6 MINUTES OF LOITER AT OPTIMUM CRUISE ALTITUDE TO 1 MINUTE OF COMBAT. SEE FIGURE 2-11FOR MISSION RULES.

FIGURE 2-10. F-5E COMBAT AIR PATROL COMBAT AND LOITER TIME WITH (3) 275-GAL TANKS



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT

2 MILITARY POWER CLIMB

3 OPTIMUM CRUISE AT CRUISE ALTITUDE NOTED

4 LOITER AT CRUISE ALTITUDE

5 DESCENT OR CLIMB TO COMBAT ALTITUDE. NO FUEL, TIME OR DISTANCE CREDIT.

6 DROP TANKS AND PYLONS AT START OF COMBAT

7 COMBAT: MAXIMUM POWER AT 15,000 FEET AT 0.80 MACH NUMBER, FIRE MISSILES AND AMMO

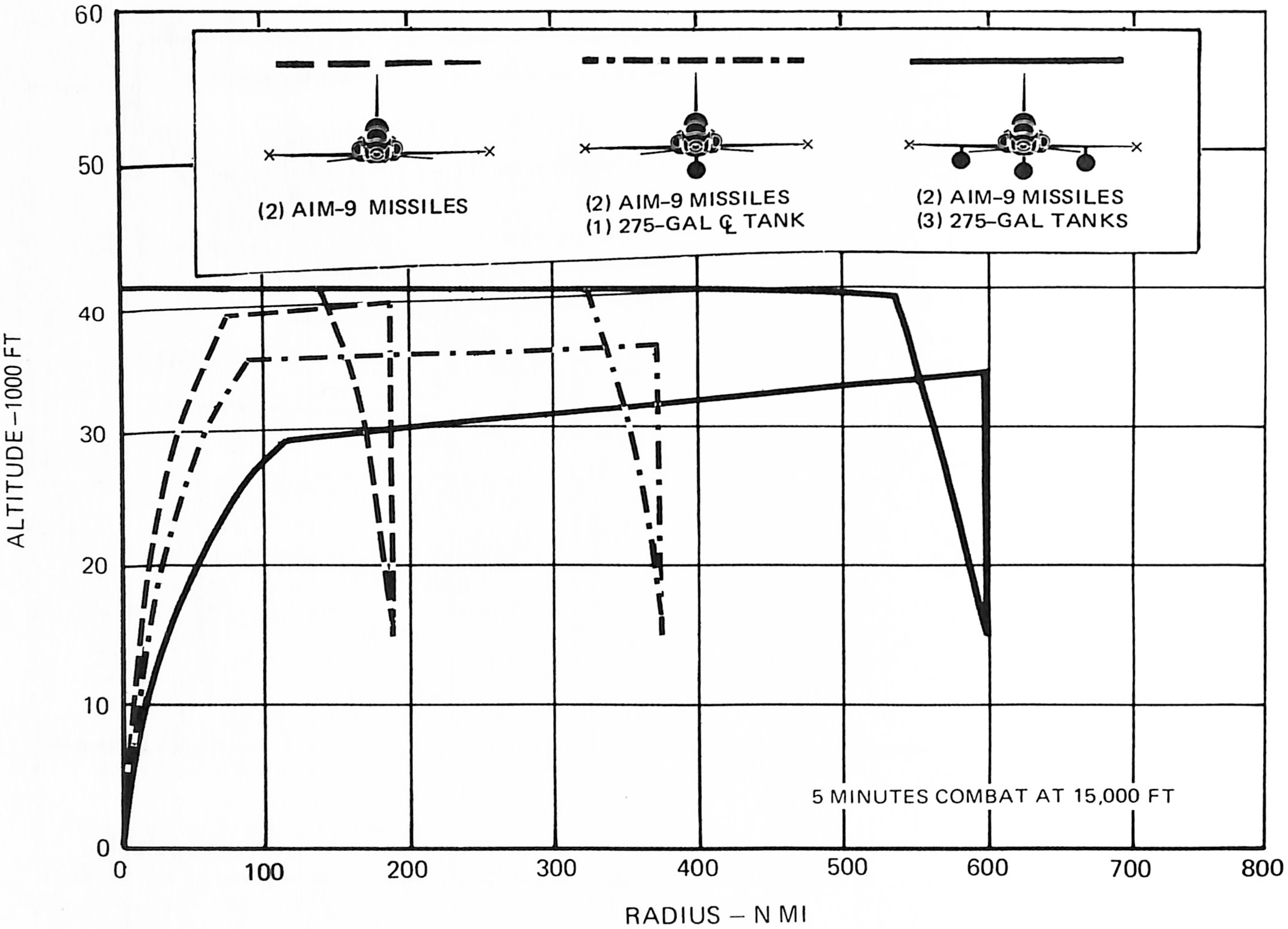
8 MILITARY POWER CLIMB TO CRUISE ALTITUDE ABOVE 15,000 FEET OR MAXIMUM RANGE DESCENT TO CRUISE ALTITUDES BELOW 15,000 FEET

9 OPTIMUM CRUISE AT CRUISE ALTITUDE

10 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT

11 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

FIGURE 2-11. F-5E COMBAT AIR PATROL MISSIONS



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT

2 MILITARY POWER CLIMB

3 OPTIMUM CRUISE AT CRUISE ALTITUDE NOTED

4 LOITER AT CRUISE ALTITUDE

5 DESCENT OR CLIMB TO COMBAT ALTITUDE. NO FUEL, TIME OR DISTANCE CREDIT.

6 DROP TANKS AND PYLONS AT START OF COMBAT

7 COMBAT: MAXIMUM POWER AT 15,000 FEET AT 0.80 MACH NUMBER, FIRE MISSILES AND AMMO

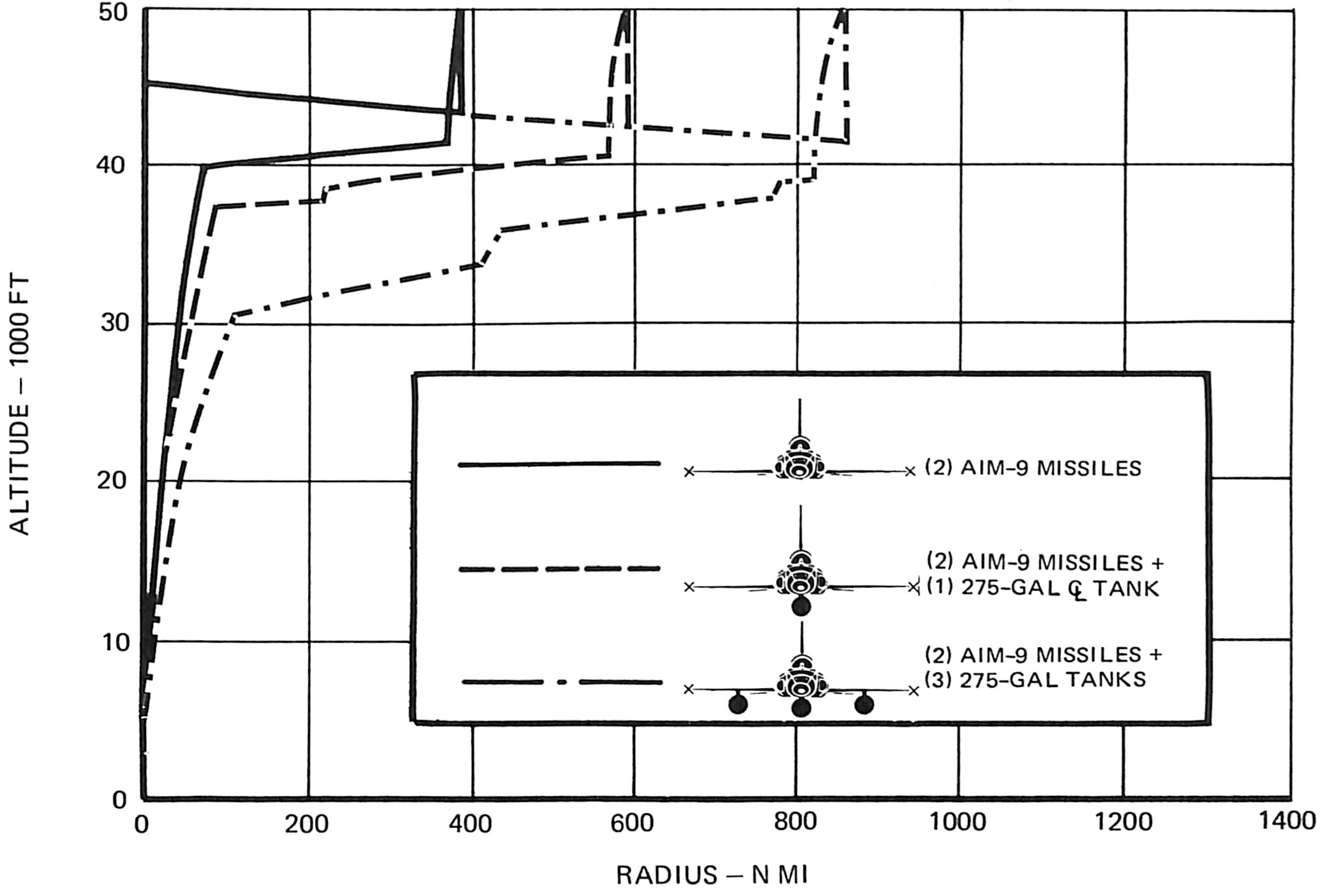
8 MILITARY POWER CLIMB TO CRUISE ALTITUDE ABOVE 15,000 FEET OR MAXIMUM RANGE DESCENT TO CRUISE ALTITUDES BELOW 15,000 FEET

9 OPTIMUM CRUISE AT CRUISE ALTITUDE

10 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT

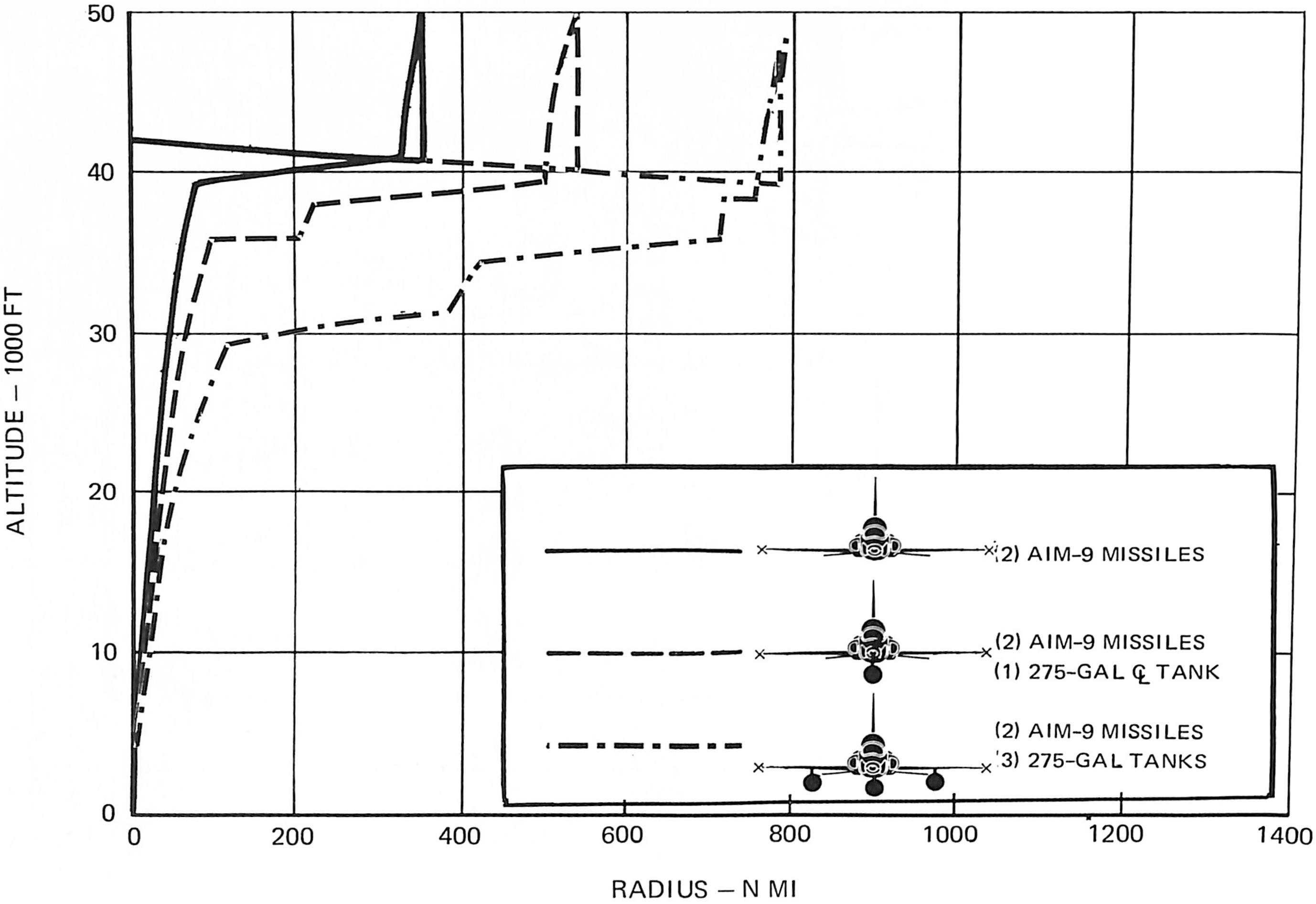
11 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

FIGURE 2-12. F-5F COMBAT AIR PATROL MISSIONS



| MISSION RULES | |
|---|---|
| 1 | TAKEOFF ALLOWANCES: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KIAS, THEN MILITARY POWER ACCELERATION TO CLIMB SPEED. NO DISTANCE CREDIT |
| 2 | MILITARY POWER CLIMB |
| 3 | DROP WING PYLON FUEL TANKS WHEN EMPTY |
| 4 | OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION |
| 5 | DROP CENTERLINE FUEL TANK AND ALL PYLONS WHEN ℄ TANK IS EMPTY |
| 6 | MAXIMUM POWER CLIMB TO 50,000 FEET OR COMBAT CEILING, WHICHEVER IS LOWER |
| 7 | COMBAT: 5 MINUTES AT COMBAT CEILING OR 50,000 FEET, WHICHEVER IS LOWER, FIRE MISSILES AND AMMO |
| 8 | OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION |
| 9 | DESCENT: NO FUEL, TIME OR DISTANCE CREDIT |
| 10 | LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL |

FIGURE 2-13. F-5E SUBSONIC AREA INTERCEPT MISSIONS



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KIAS, THEN MILITARY POWER ACCELERATION TO CLIMB SPEED. NO DISTANCE CREDIT

2 MILITARY POWER CLIMB

3 DROP WING PYLON FUEL TANKS WHEN EMPTY

4 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

5 DROP CENTERLINE FUEL TANK AND ALL PYLONS WHEN ℄ TANK IS EMPTY

6 MAXIMUM POWER CLIMB TO 50,000 FEET OR COMBAT CEILING, WHICHEVER IS LOWER

7 COMBAT: 5 MINUTES AT COMBAT CEILING OR 50,000 FEET, WHICHEVER IS LOWER, FIRE MISSILES AND AMMO

8 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

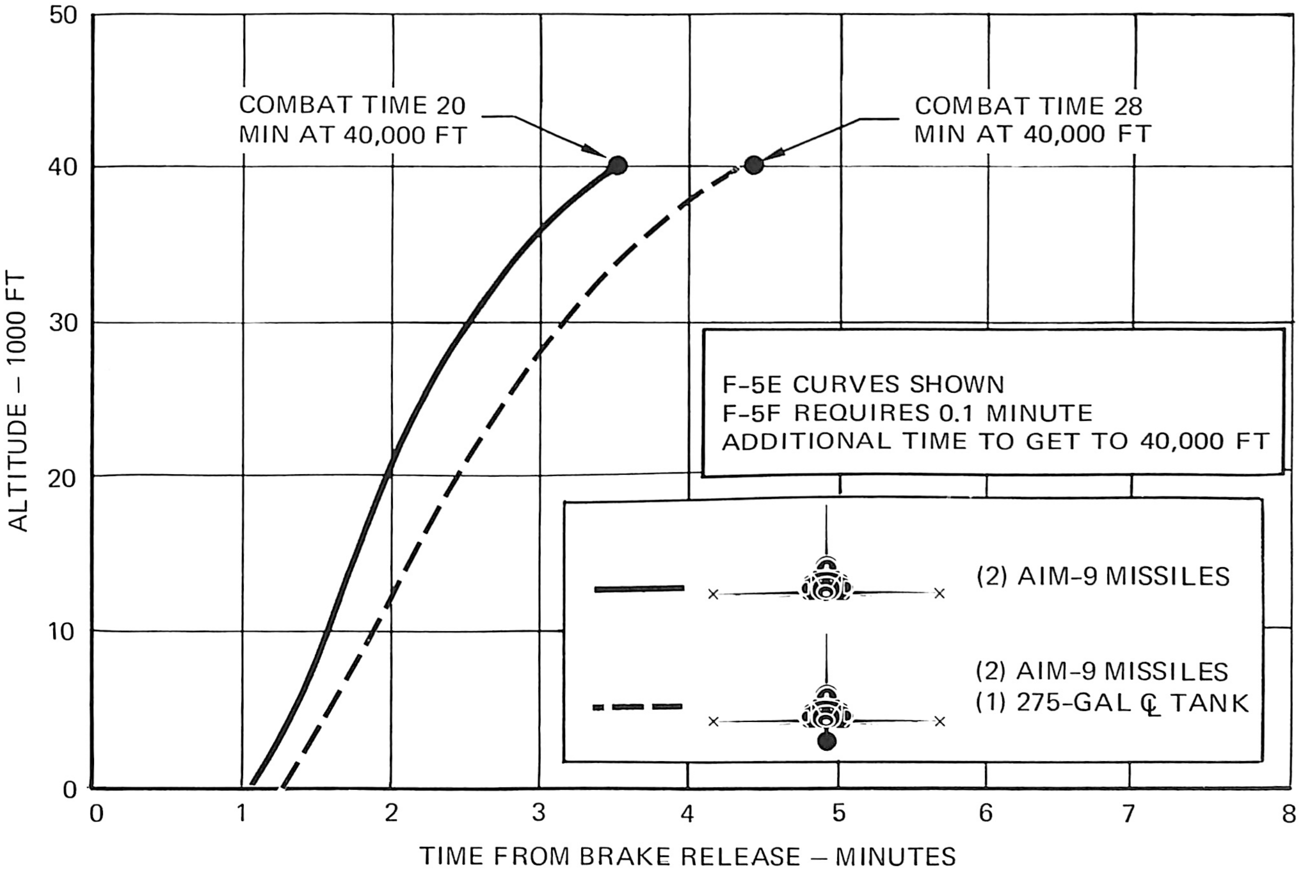
9 DESCENT: NO FUEL, TIME OR DISTANCE CREDIT

10 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

FIGURE 2-14. F-5F SUBSONIC AREA INTERCEPT MISSIONS

## Subsonic Point Intercept Mission

The minimum subsonic point intercept time, along with combat time duration on station at 40,000 feet, is shown in Figure 2-15 for both the F-5E and F-5F, for the missiles-only and the missiles-plus-centerline-tank configurations. The F-5F is 0.1 minute slower getting to 40,000 feet than the F-5E.



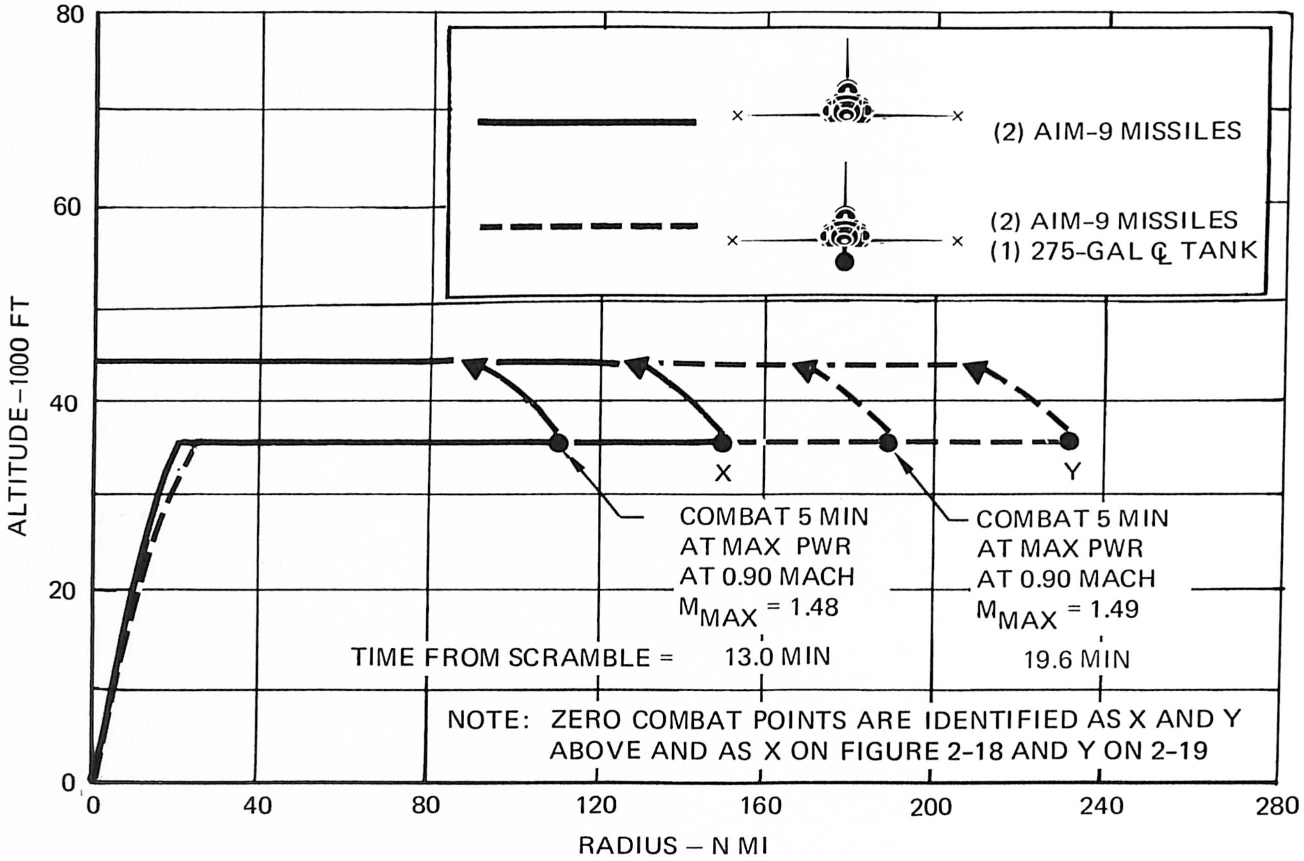
MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO CLIMB SPEED, NO DISTANCE CREDIT
2 MAXIMUM POWER CLIMB TO 40,000 FEET
3 COMBAT AT MAXIMUM POWER, FIRE AMMO AND MISSILES
4 LANDING RESERVE: FUEL FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL
5 DROP ℄ TANK AND PYLON AT START OF COMBAT

FIGURE 2-15. F-5E/F SUBSONIC POINT INTERCEPT MISSIONS

## Supersonic Intercept Mission

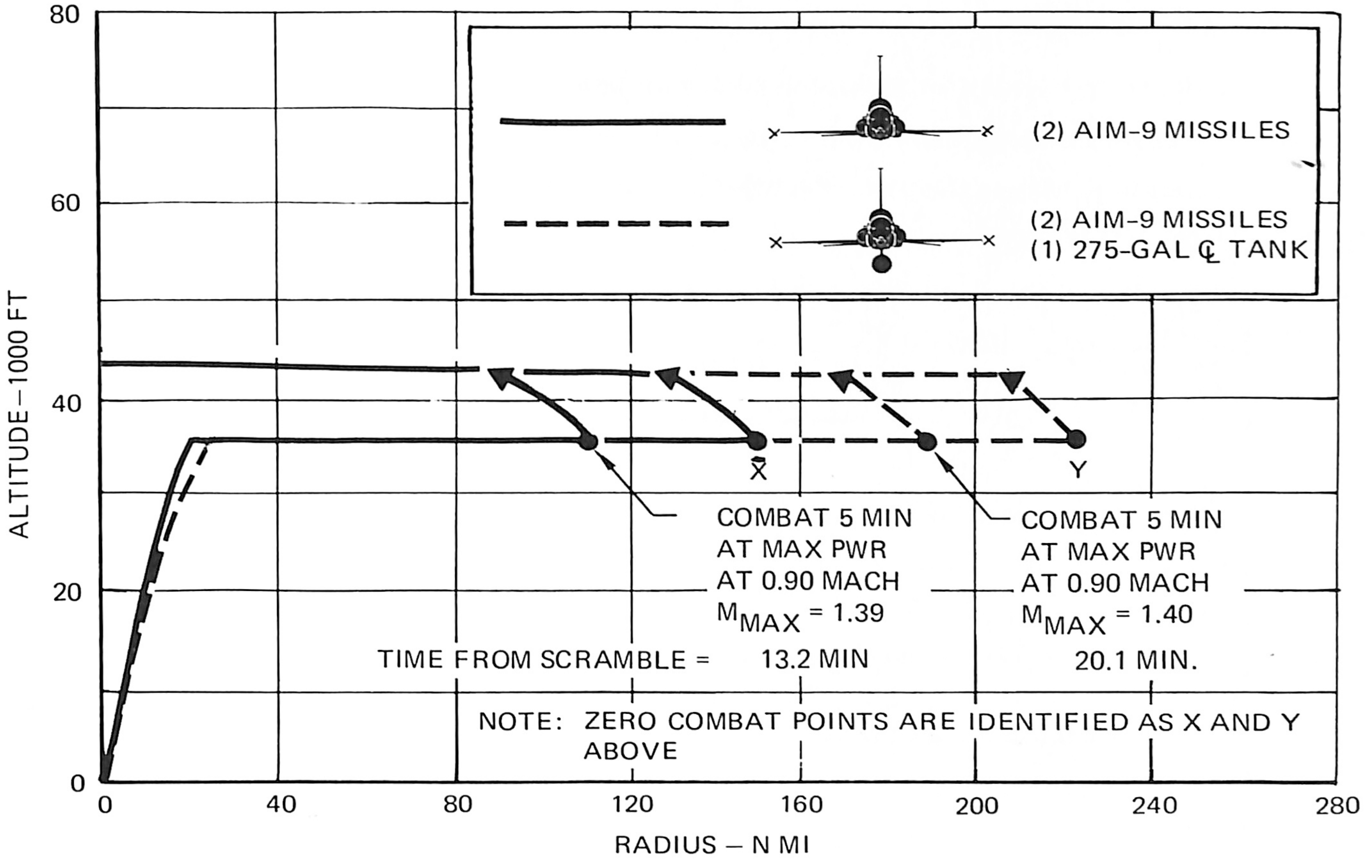
Typical supersonic intercept mission profiles are presented for the F-5E in Figure 2-16 and for the F-5F in Figure 2-17 for the missiles-only and missiles-plus-centerline-tank configurations. Profiles are presented for five minutes combat and also for zero combat time.



MISSION RULES

1 TIME FOR SCRAMBLE 2.6 MINUTES
2 TAKEOFF ALLOWANCES: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATION TO CLIMB SPEED. NO DISTANCE CREDIT
3 MAXIMUM POWER CLIMB TO ALTITUDE
4 MAXIMUM POWER ACCELERATION TO $V_{MAX}$
5 DROP TANK AND PYLON WHEN TANK IS EMPTY
6 COMBAT: MAXIMUM POWER, FIRE MISSILES AND AMMO
7 MILITARY POWER CLIMB TO OPTIMUM CRUISE ALTITUDE
8 OPTIMUM CRUISE
9 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT
10 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

FIGURE 2-16. F-5E SUPERSONIC INTERCEPT MISSIONS



MISSION RULES

1. TIME FOR SCRAMBLE 2.6 MINUTES
2. TAKEOFF ALLOWANCES: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATION TO CLIMB SPEED. NO DISTANCE CREDIT
3. MAXIMUM POWER CLIMB TO ALTITUDE
4. MAXIMUM POWER ACCELERATION TO $V_{MAX}$
5. DROP TANK AND PYLON WHEN TANK IS EMPTY
6. COMBAT: MAXIMUM POWER, FIRE MISSILES AND AMMO
7. MILITARY POWER CLIMB TO OPTIMUM CRUISE ALTITUDE
8. OPTIMUM CRUISE
9. DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT
10. LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

FIGURE 2-17. F-5F SUPERSONIC INTERCEPT MISSIONS

## Subsonic and Supersonic Intercept Envelopes

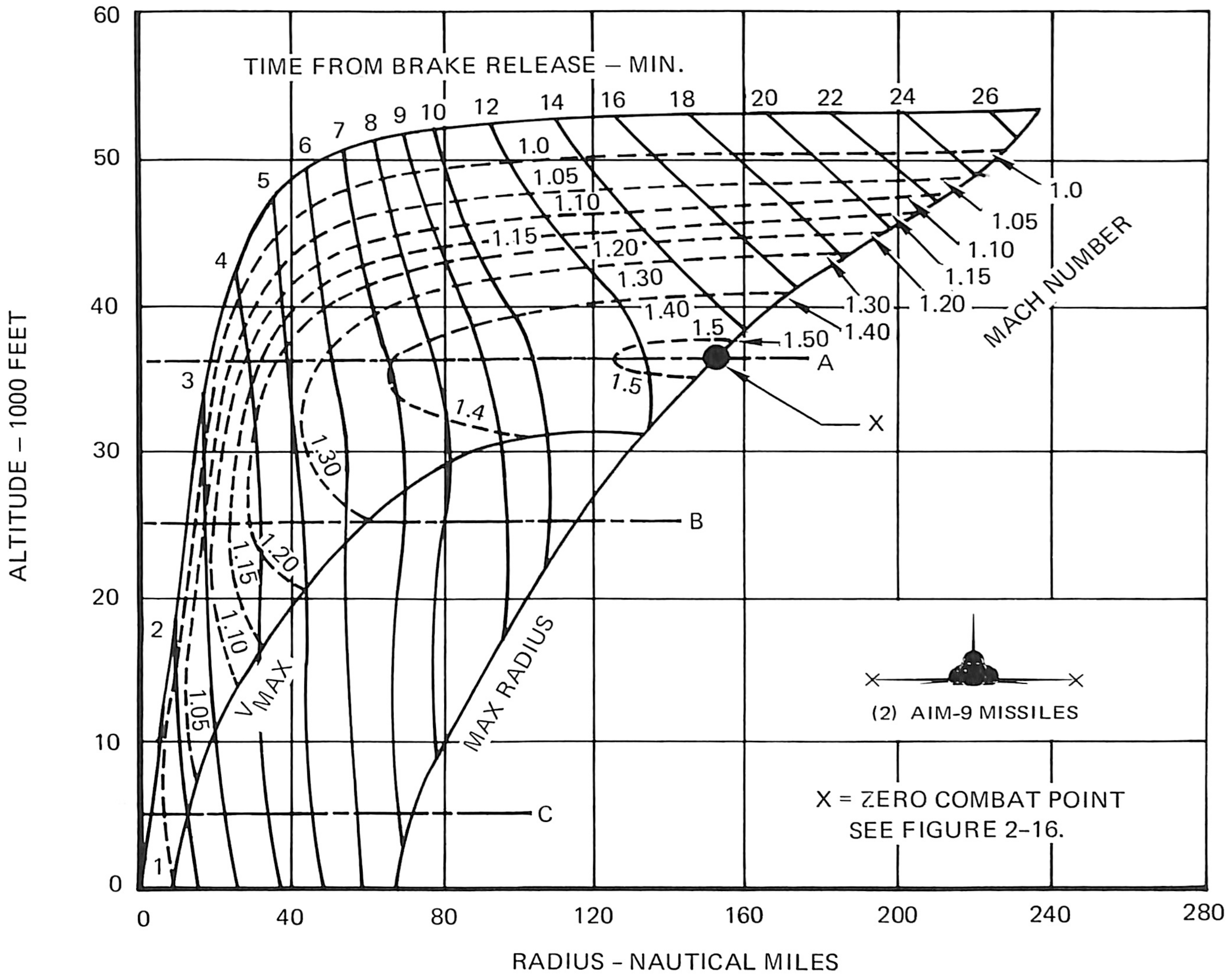
The F-5E intercept radius envelopes shown in Figures 2-18 through 2-21 present intercept radius as a function of constant altitude, with acceleration to $V_{max}$ or to the maximum radius, depending on the altitude. Intercept envelopes are shown for two configurations and both maximum and military power accelerations to the target. One configuration has AIM-9 missiles only and the other carries missiles and a 275-gallon centerline fuel tank. The tank and pylon are jettisoned when the tank is empty.

Line "A" on Figure 2-18 illustrates a maximum power climb to 36,089 feet and acceleration, at maximum thrust, to 1.51 Mach at 151 nautical miles at point "X" 13.0 minutes from brake release. Line "B" on Figure 2-18, at 25,000 feet, indicates that at this altitude the airplane can reach 1.29 Mach maximum at 61 nautical miles in 6.4 minutes from brake release, and continue at that speed to a maximum radius of 115 nautical miles in 10.6 minutes from brake release.

At the maximum radius there is no combat time available; however, the charts provide an approximate method to exchange radius for combat time. From Figure 2-18 for example, only 10.2 minutes are required to reach 100 nautical miles at 40,000 feet, leaving better than five minutes for supersonic combat. A greater mission radius or increased combat time with either maximum or military power acceleration can be obtained with the centerline tank, as shown in Figure 2-19 and 2-21.

Increased intercept mission radius can also be obtained by accelerating and combating with military power, as shown on Figures 2-20 and 2-21. This is particularly important at the lower altitudes, where throttling back to military power significantly reduces fuel flow but with a much smaller percentage reduction in speed. Also, at the lower altitudes, the elapsed times to intercept at military power approach those for a maximum power intercept.

Line "C" is drawn on Figures 2-18 and 2-20 to allow comparison of the F-5E AIM-9 missiles-only configuration performance at maximum and military power at 5000 feet altitude. In the maximum power case (Figure 2-18), the F-5E reaches 1.03 Mach in 2.2 minutes and has a radius capability of 70 nautical miles, approximately 7.4 minutes from brake release. Using military power (Figure 2-20), the F-5E accelerates to 0.93 Mach and reaches the 70-nautical-mile point eight minutes from brake release, an increase of only 36 seconds. In addition, the F-5E has the capability at this altitude and speed of reaching a radius of 177 nautical miles 18.6 minutes from brake release. Addition of the centerline tank increases the F-5E military power radius at 5000 feet to 275 nautical miles (Figure 2-21).



MISSION RULES

1 TAKEOFF ALLOWANCE: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM THRUST TAKEOFF AND ACCELERATION TO CLIMB SPEED. NO DISTANCE CREDIT

2 MAXIMUM POWER CLIMB TO ALTITUDE

3 MAXIMUM POWER ACCELERATION TO $V_{MAX}$

4 MAXIMUM POWER CRUISE TO TARGET

5 FIRE MISSILES AND AMMO

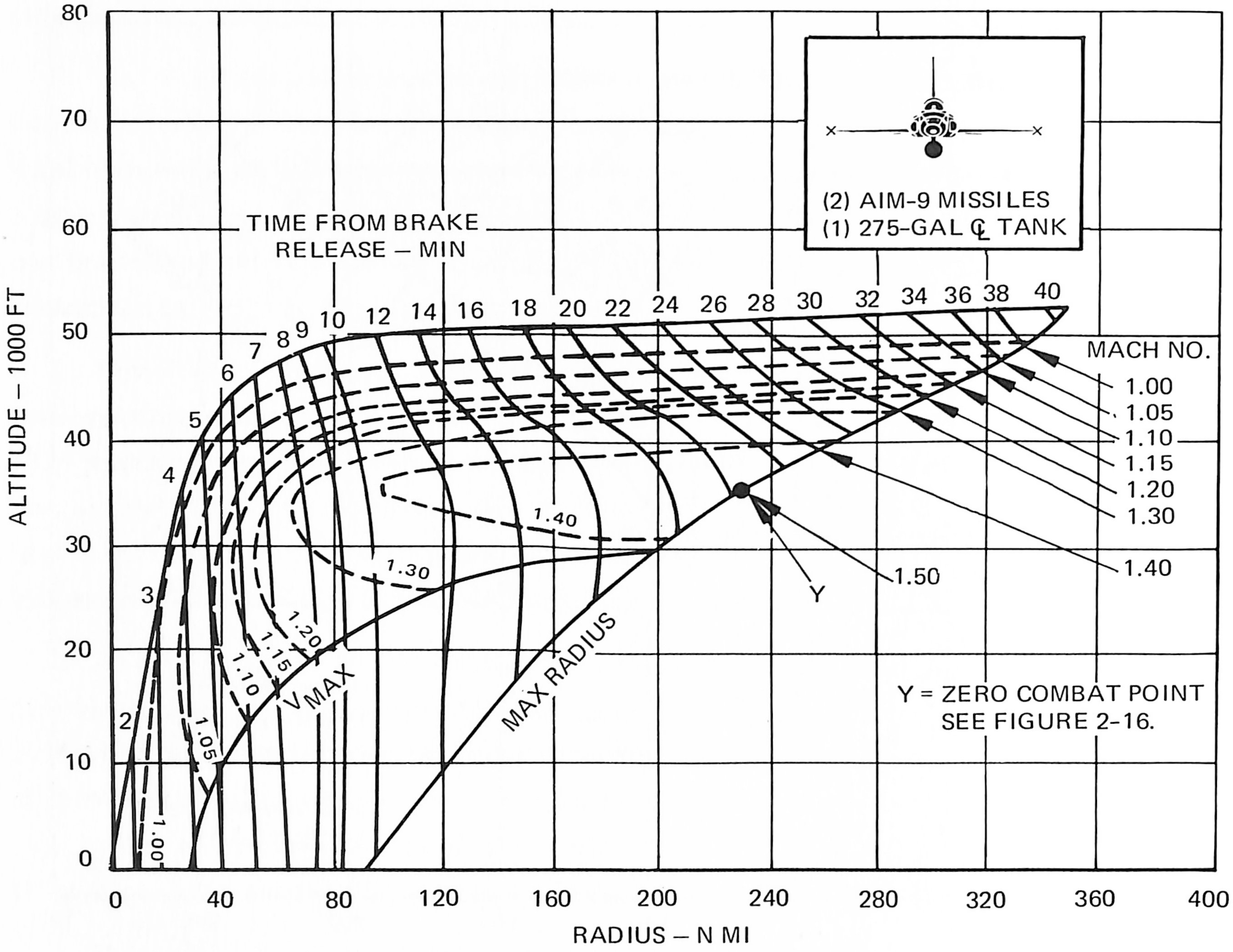
6 MILITARY POWER CLIMB

7 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

8 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT

9 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

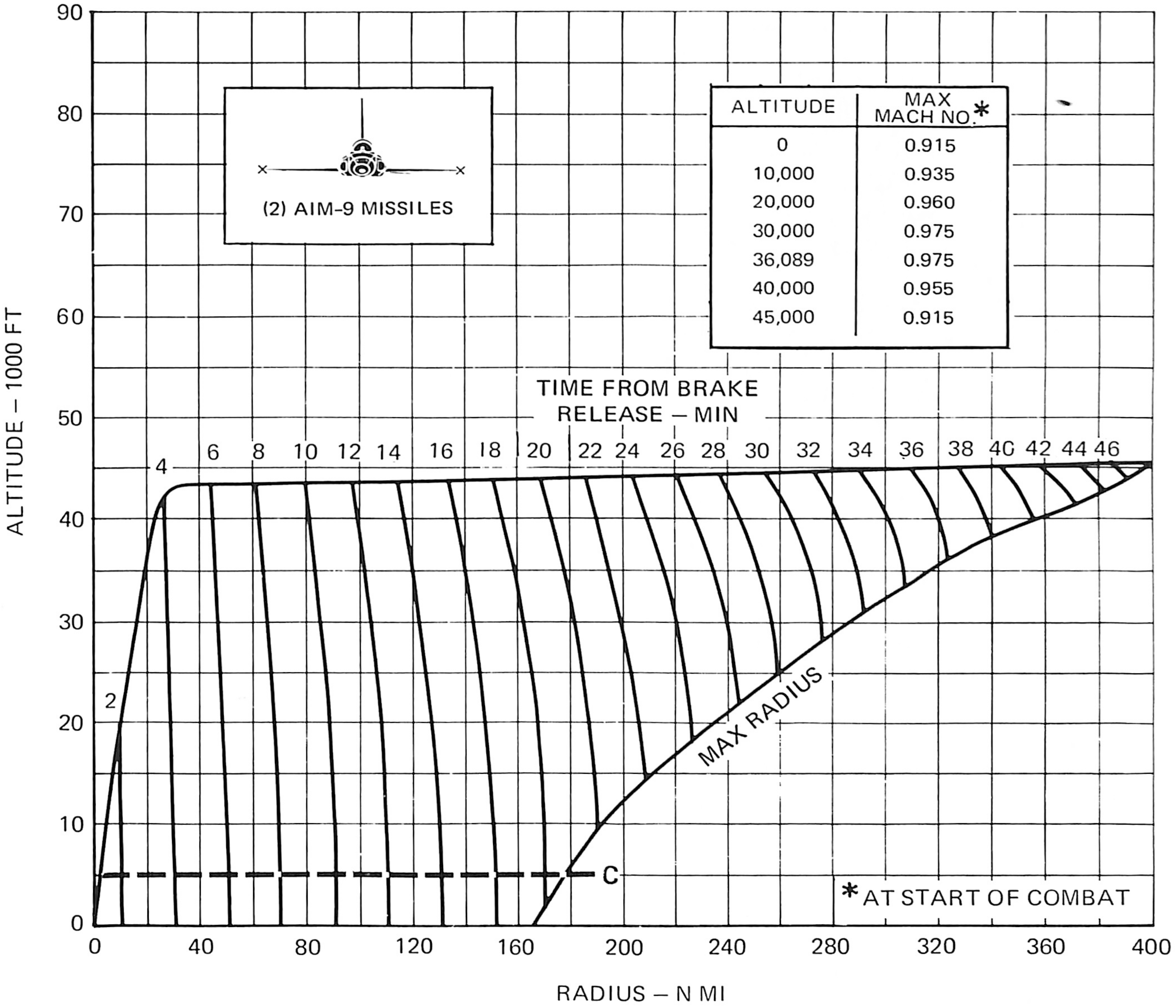
FIGURE 2-18. F-5E MAXIMUM POWER INTERCEPT RADIUS ENVELOPE



MISSION RULES

1 TAKEOFF ALLOWANCE: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM THRUST TAKEOFF AND ACCELERATION TO CLIMB SPEED. NO DISTANCE CREDIT
2 MAXIMUM POWER CLIMB TO ALTITUDE
3 MAXIMUM POWER ACCELERATION TO $V_{MAX}$
4 MAXIMUM POWER CRUISE TO TARGET
5 DROP TANK AND PYLON WHEN TANK IS EMPTY
6 FIRE MISSILES AND AMMO
7 MILITARY POWER CLIMB
8 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION
9 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT
10 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

FIGURE 2-19. F-5E MAXIMUM POWER INTERCEPT RADIUS ENVELOPE (275-GAL ℄ TANK)



| ALTITUDE | MAX MACH NO.* |
|---|---|
| 0 | 0.915 |
| 10,000 | 0.935 |
| 20,000 | 0.960 |
| 30,000 | 0.975 |
| 36,089 | 0.975 |
| 40,000 | 0.955 |
| 45,000 | 0.915 |

*AT START OF COMBAT

MISSION RULES

1 TAKEOFF ALLOWANCE: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO CLIMB SPEED. NO DISTANCE CREDIT

2 MAXIMUM POWER CLIMB TO ALTITUDE

3 MILITARY POWER ACCELERATION TO $M_{MAX}$

4 MILITARY POWER CRUISE TO TARGET

5 FIRE MISSILES AND AMMO AT TARGET

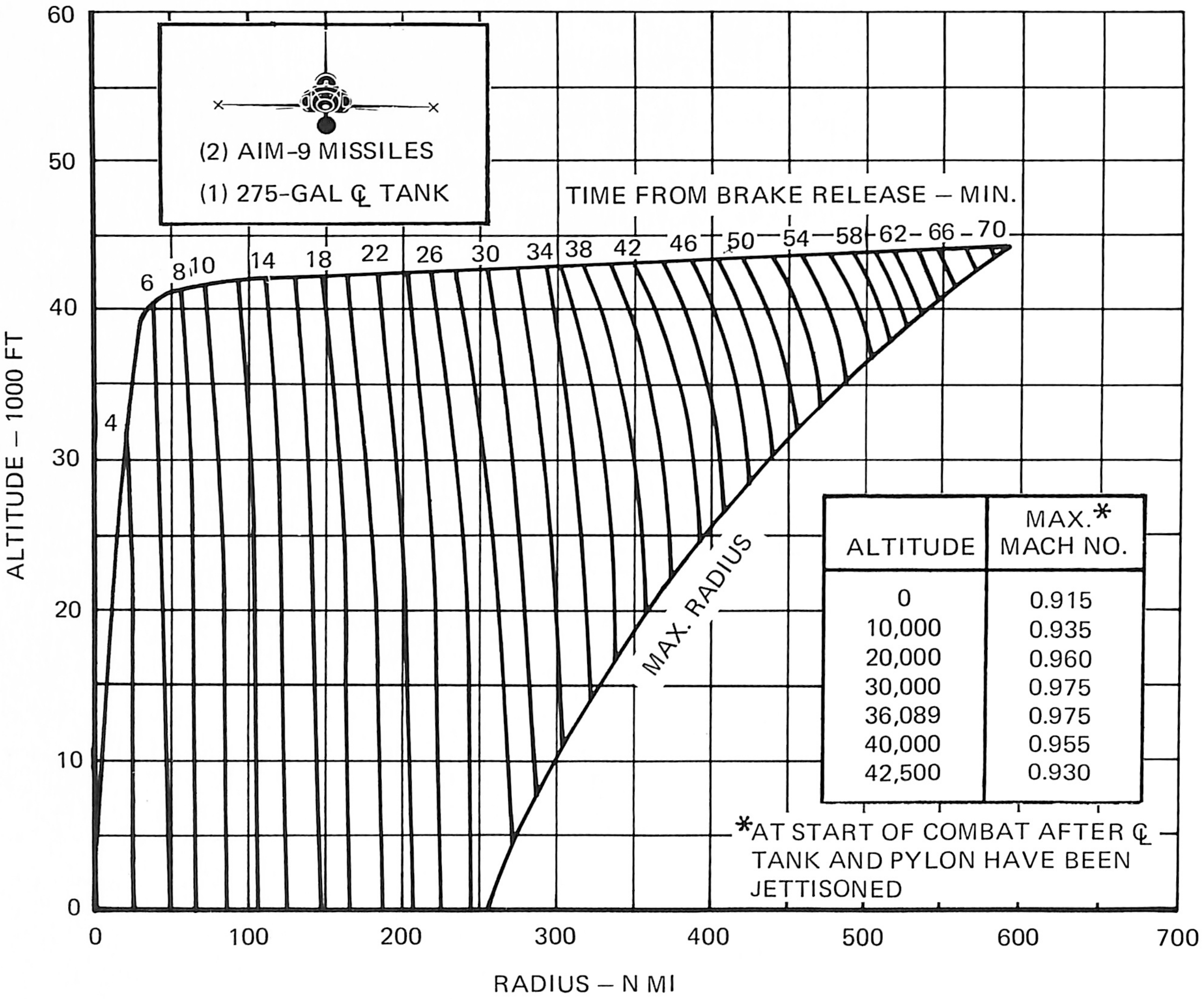
6 MILITARY POWER CLIMB

7 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

8 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT

9 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

**FIGURE 2-20. F-5E MILITARY POWER INTERCEPT RADIUS ENVELOPE**



| ALTITUDE | MAX.* MACH NO. |
|---|---|
| 0 | 0.915 |
| 10,000 | 0.935 |
| 20,000 | 0.960 |
| 30,000 | 0.975 |
| 36,089 | 0.975 |
| 40,000 | 0.955 |
| 42,500 | 0.930 |

*AT START OF COMBAT AFTER ℄ TANK AND PYLON HAVE BEEN JETTISONED

MISSION RULES

1 TAKEOFF ALLOWANCE: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO CLIMB SPEED. NO DISTANCE CREDIT
2 MAXIMUM POWER CLIMB TO ALTITUDE
3 MILITARY POWER ACCELERATION TO $M_{MAX}$
4 MILITARY POWER CRUISE TO TARGET
5 DROP CENTERLINE TANK (WHEN EMPTY) AND PYLON
6 FIRE MISSILES AND AMMO AT TARGET
7 MILITARY POWER CLIMB
8 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION
9 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT
10 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

FIGURE 2-21. F-5E MILITARY POWER INTERCEPT RADIUS ENVELOPE (275-GAL ℄ TANK)

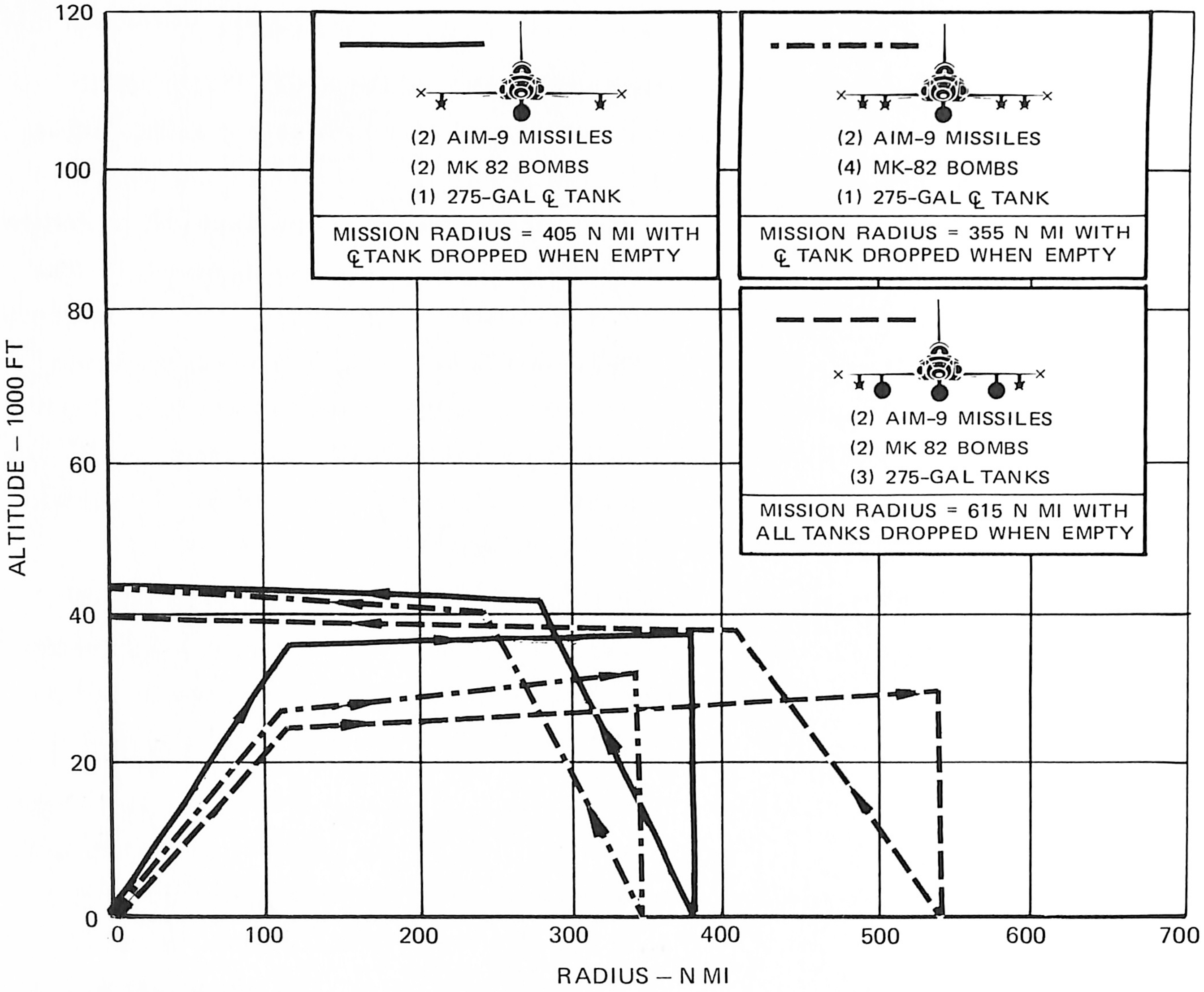
## Interdiction Missions

The interdiction missions demonstrate the ability of the F-5E/F aircraft to deliver a given payload over long distances where no loiter is required at the target. HI-LO-HI missions are used when optimum cruise is required both to and from the target to obtain maximum radius. The low-altitude (sea level) optimum cruise outbound is used to minimize airplane detection prior to bomb drop (LO-LO-HI profile). The mission return is at high altitude optimum cruise. Sea level cruise, both to and from the target, is demonstrated by the LO-LO-LO profiles. These missions are flown when minimum aircraft detection is desired both to and from the target area. Typical mission profiles are shown for the F-5E and F-5F in Figures 2-22 through 2-29. The effects of low altitude (sea level) outbound cruise Mach number on the LO-LO-HI and LO-LO-LO profiles are provided for the F-5E in Figure 2-30.

Mission time as a function of interdiction mission radius for various MK-82 bomb loadings for the HI-LO-HI profile is shown for the F-5E in Figure 2-31 and the F-5F in Figure 2-32. The 20-minute sea level loiter landing reserve time is not included in the total mission time.

HI-LO-HI mission ordnance load-radius curves for single MK-series low drag bomb loadings are presented for the F-5E in Figure 2-33 and the F-5F in Figure 2-34. Figure 2-34 shows that the F-5F has a 135-nautical-mile radius with a single MK series (growth) ordnance load of 6000 pounds. The two AIM-9 missiles are not included in this 6000-pound ordnance load because they are strictly air-to-air weapons. These curves are smooth fairings of discrete mission radii points.

Figure 2-35 shows multiple MK-series bomb loadings (growth) for the F-5E. The figure shows that the F-5E has a 120-nautical-mile radius with a multiple MK series (growth) ordnance load of approximately 7000 pounds composed of four 1000-pound-class bombs, five 500-pound-class bombs, and a full load of 560 rounds of 20mm ammunition. Again, the two AIM-9 missiles are not included in the approximately 7000-pound air-to-ground ordnance load. These curves are also smooth fairings of discrete mission radii points.



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS. THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT.

2 MILITARY POWER CLIMB

3 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

4 DESCENT: TO SEA LEVEL, NO FUEL, TIME OR DISTANCE CREDIT

5 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO. MISSILES RETAINED.

6 MILITARY POWER CLIMB

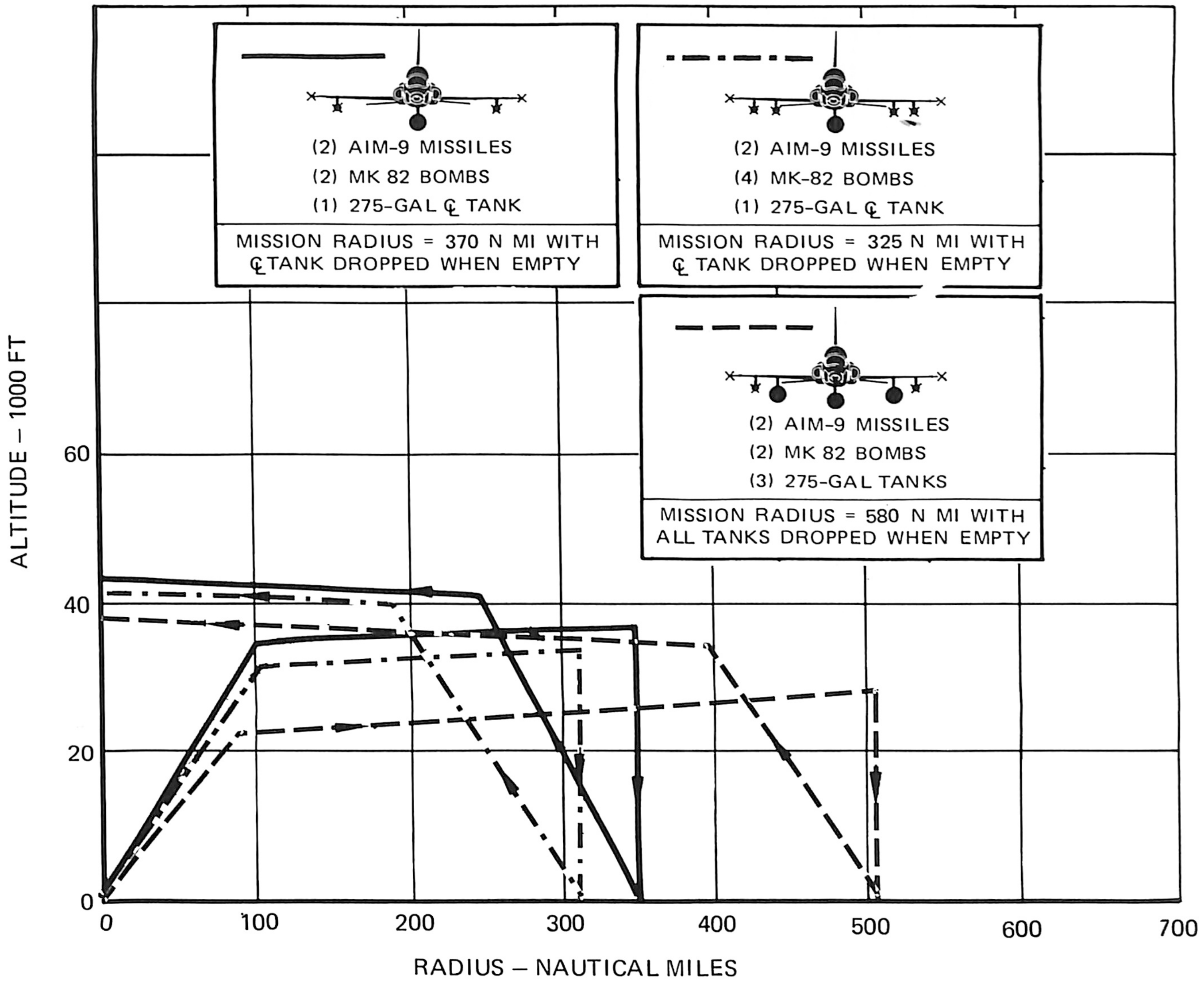
7 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

8 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT

9 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

10 TANKS AND PYLONS RETAINED

FIGURE 2-22. F-5E INTERDICTION MISSION (HI-LO-HI)



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS. THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT.

2 MILITARY POWER CLIMB

3 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

4 DESCENT: TO SEA LEVEL, NO FUEL, TIME OR DISTANCE CREDIT

5 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO. MISSILES RETAINED.

6 MILITARY POWER CLIMB

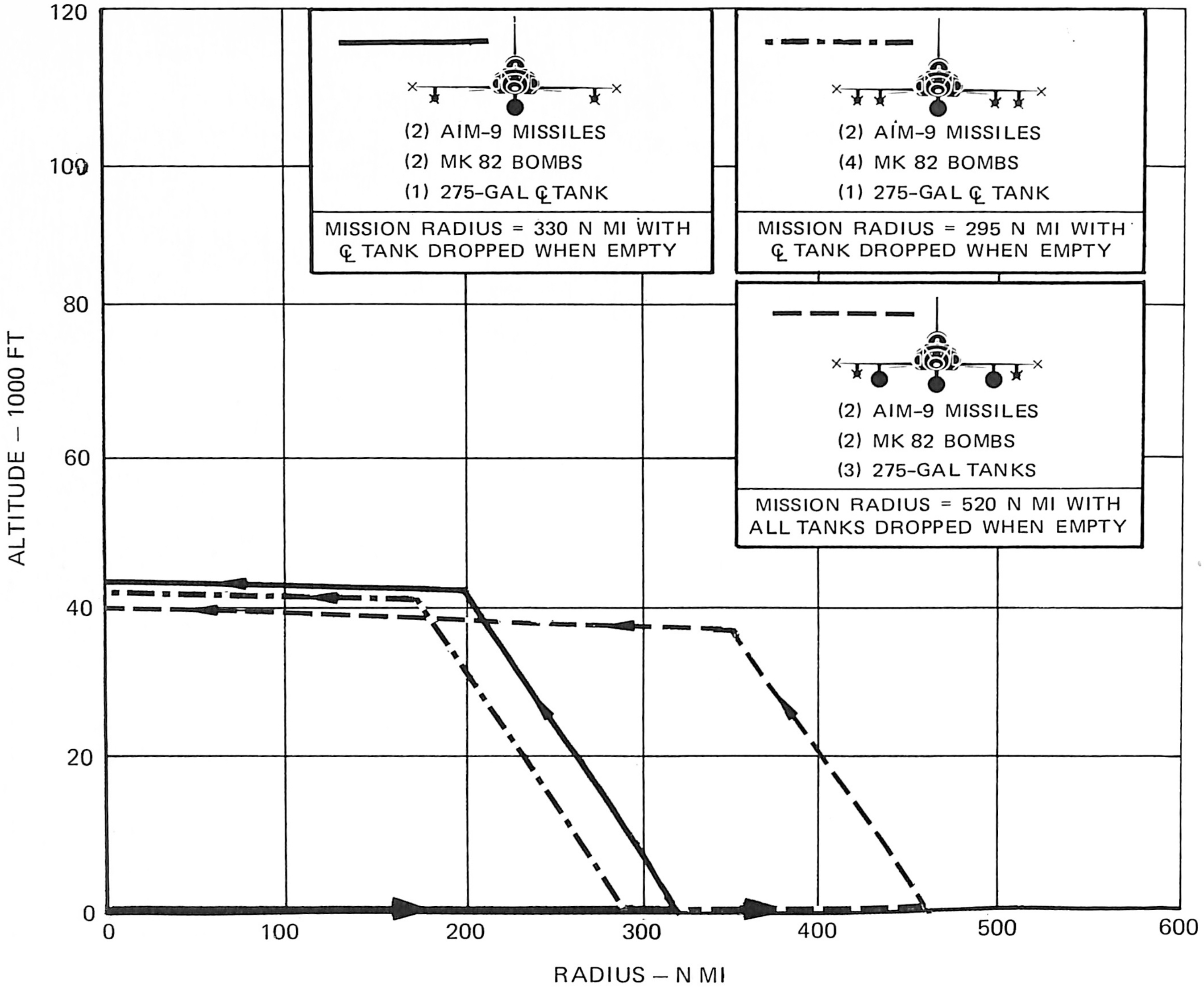
7 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

8 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT

9 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

10 TANKS AND PYLONS RETAINED

FIGURE 2-23. F-5F INTERDICTION MISSION (HI-LO-HI)



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT.

2 OPTIMUM CRUISE AT SEA LEVEL.

3 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO.

4 MILITARY POWER CLIMB.

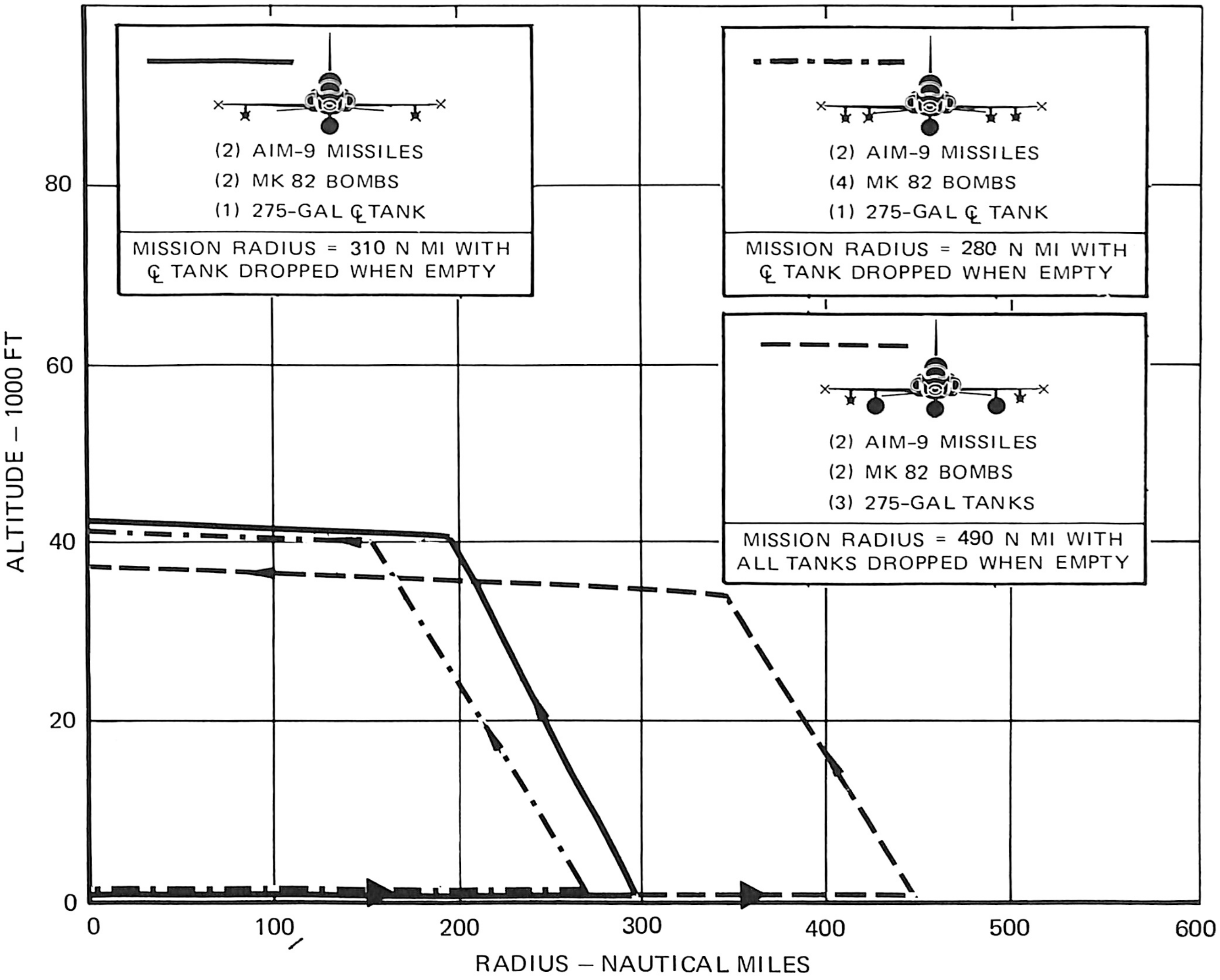
5 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION.

6 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT.

7 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.

8 TANKS AND PYLONS RETAINED.

FIGURE 2-24. F-5E INTERDICTION MISSION (LO-LO-HI)



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT.

2 OPTIMUM CRUISE AT SEA LEVEL.

3 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO.

4 MILITARY POWER CLIMB.

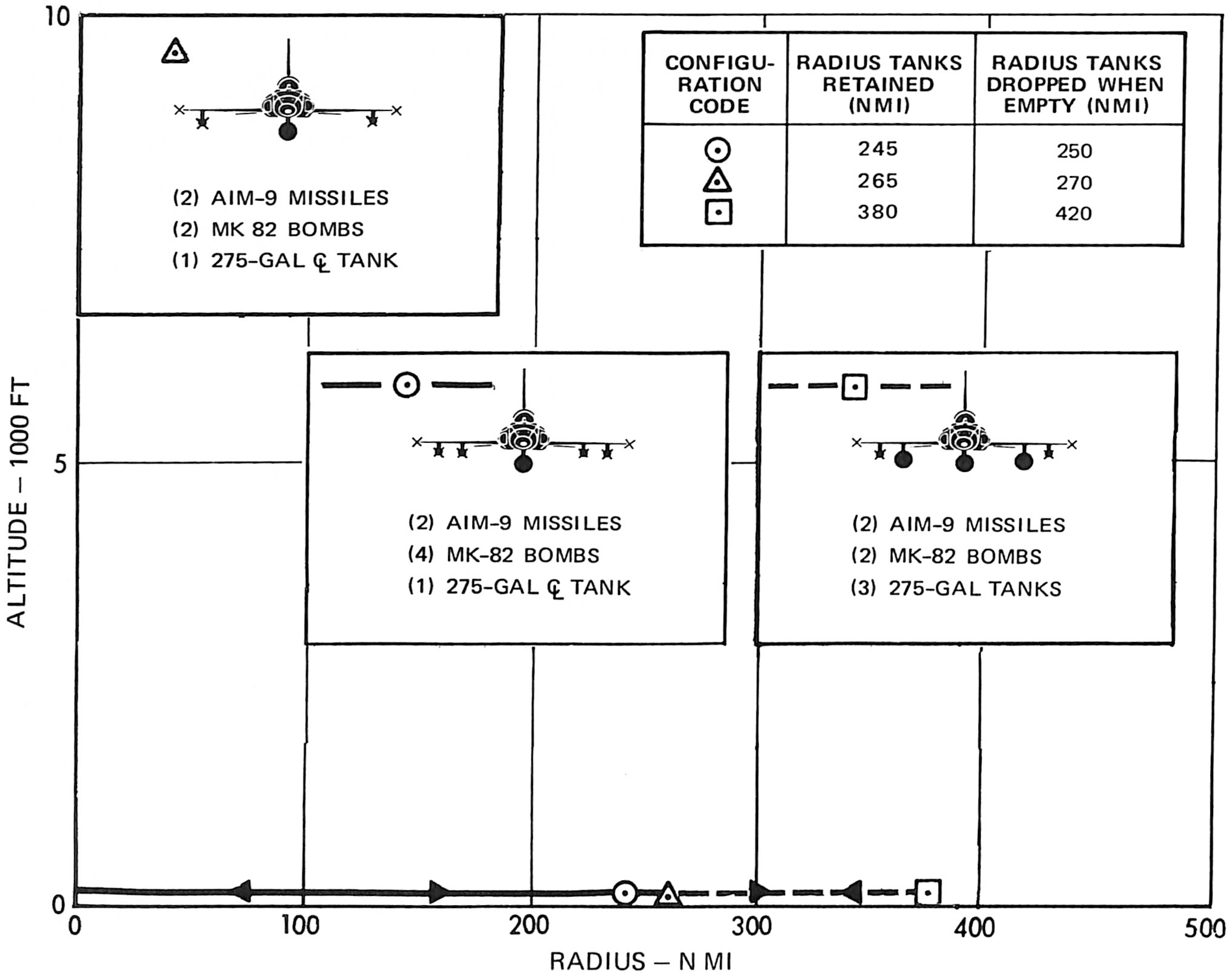
5 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION.

6 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT.

7 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.

8 TANKS AND PYLONS RETAINED.

FIGURE 2-25. F-5F INTERDICTION MISSION (LO-LO-HI)



| CONFIGURATION CODE | RADIUS TANKS RETAINED (NMI) | RADIUS TANKS DROPPED WHEN EMPTY (NMI) |
|---|---|---|
| ⊙ | 245 | 250 |
| ◬ | 265 | 270 |
| ⊡ | 380 | 420 |

MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT.

2 OPTIMUM CRUISE AT SEA LEVEL.

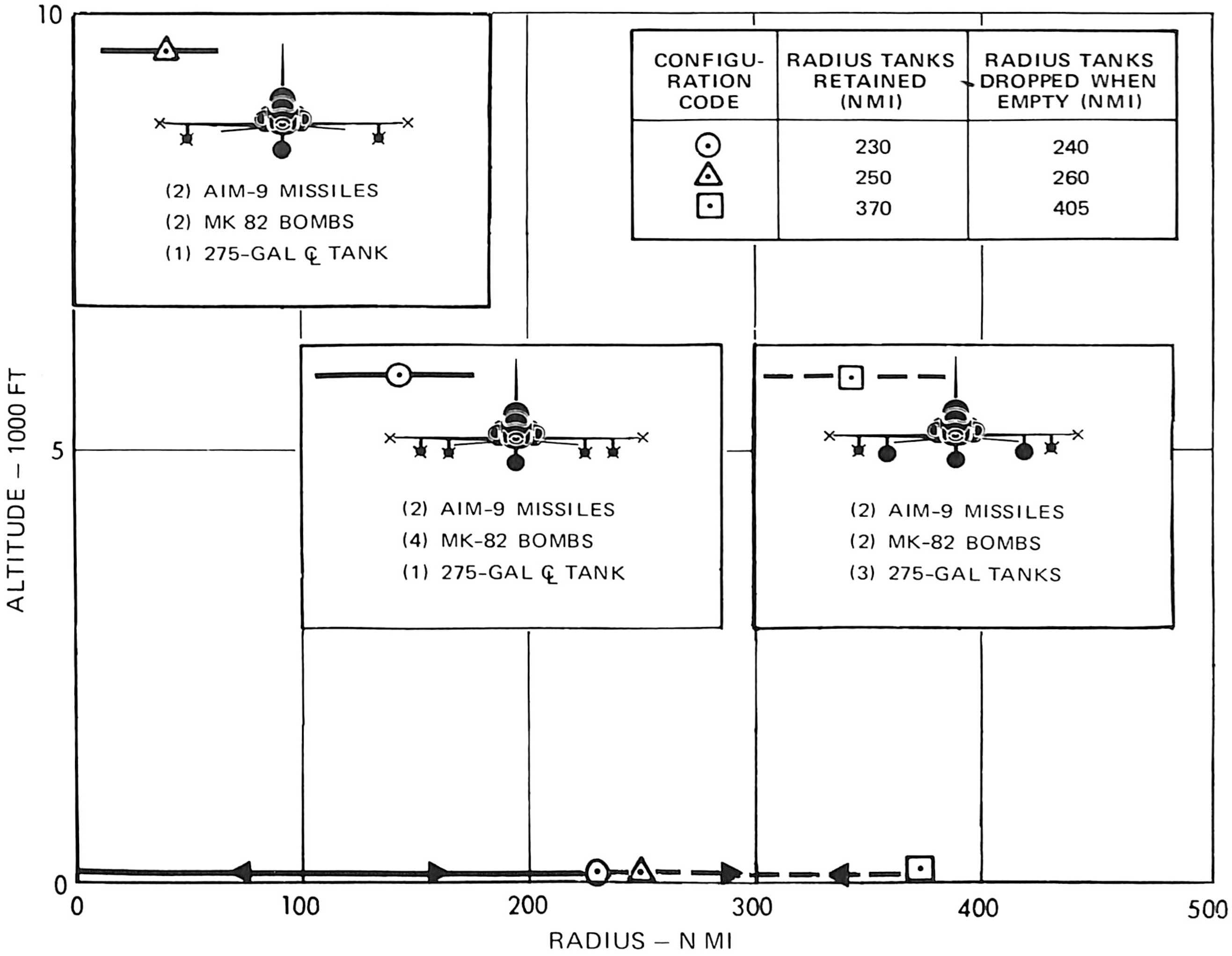
3 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO. MISSILES RETAINED.

4 OPTIMUM CRUISE AT SEA LEVEL.

5 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.

6 TANKS AND PYLONS RETAINED.

FIGURE 2-26. F-5E INTERDICTION MISSION (LO-LO-LO) MAXIMUM FUEL LOAD



| CONFIGURATION CODE | RADIUS TANKS RETAINED (NMI) | RADIUS TANKS DROPPED WHEN EMPTY (NMI) |
|---|---|---|
| ⊙ | 230 | 240 |
| △ | 250 | 260 |
| ⊡ | 370 | 405 |

MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT.

2 OPTIMUM CRUISE AT SEA LEVEL.

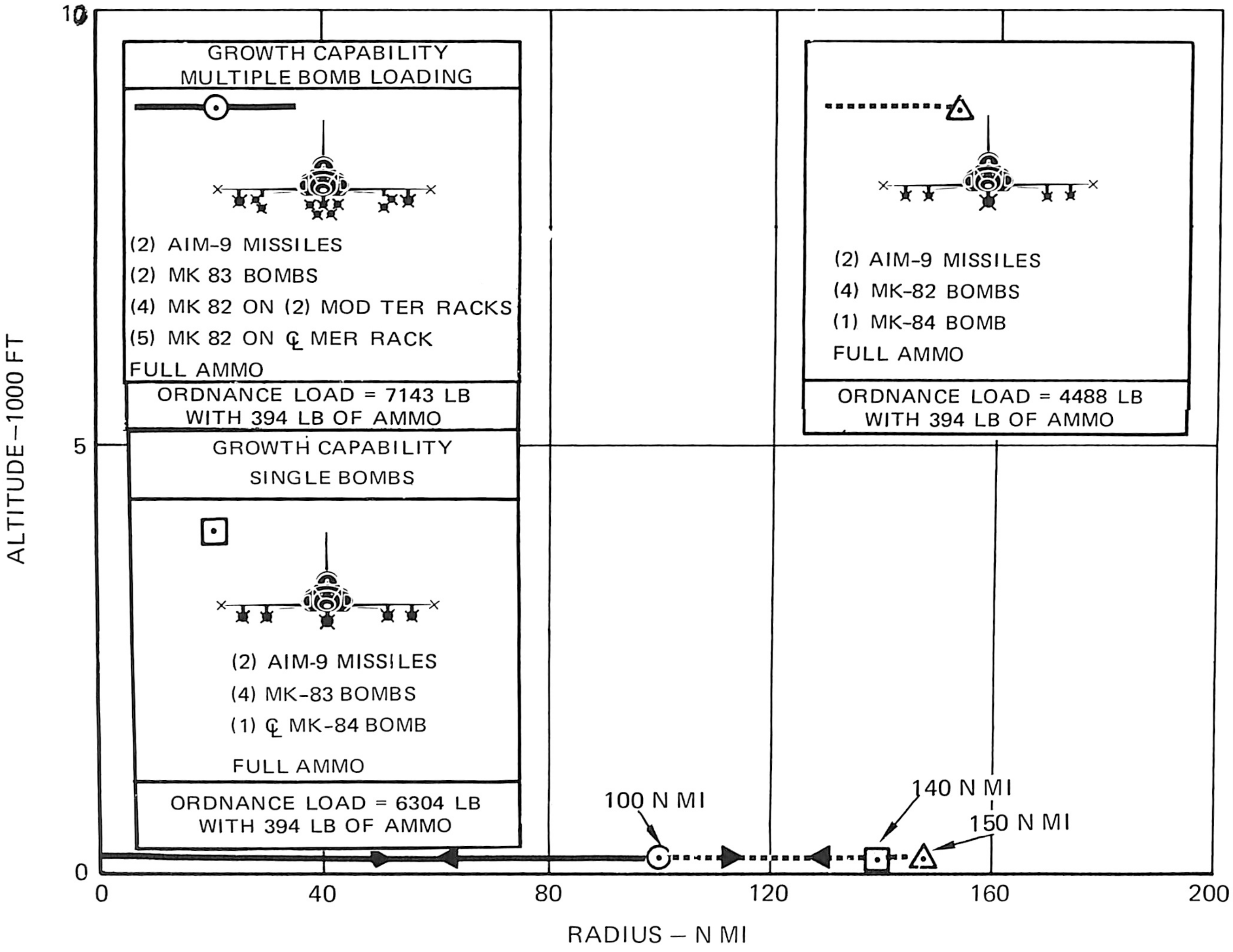
3 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO. MISSILES RETAINED.

4 OPTIMUM CRUISE AT SEA LEVEL.

5 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.

6 TANKS AND PYLONS RETAINED.

FIGURE 2-27. F-5F INTERDICTION MISSION (LO-LO-LO) MAXIMUM FUEL LOAD



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER. MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS. THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT.

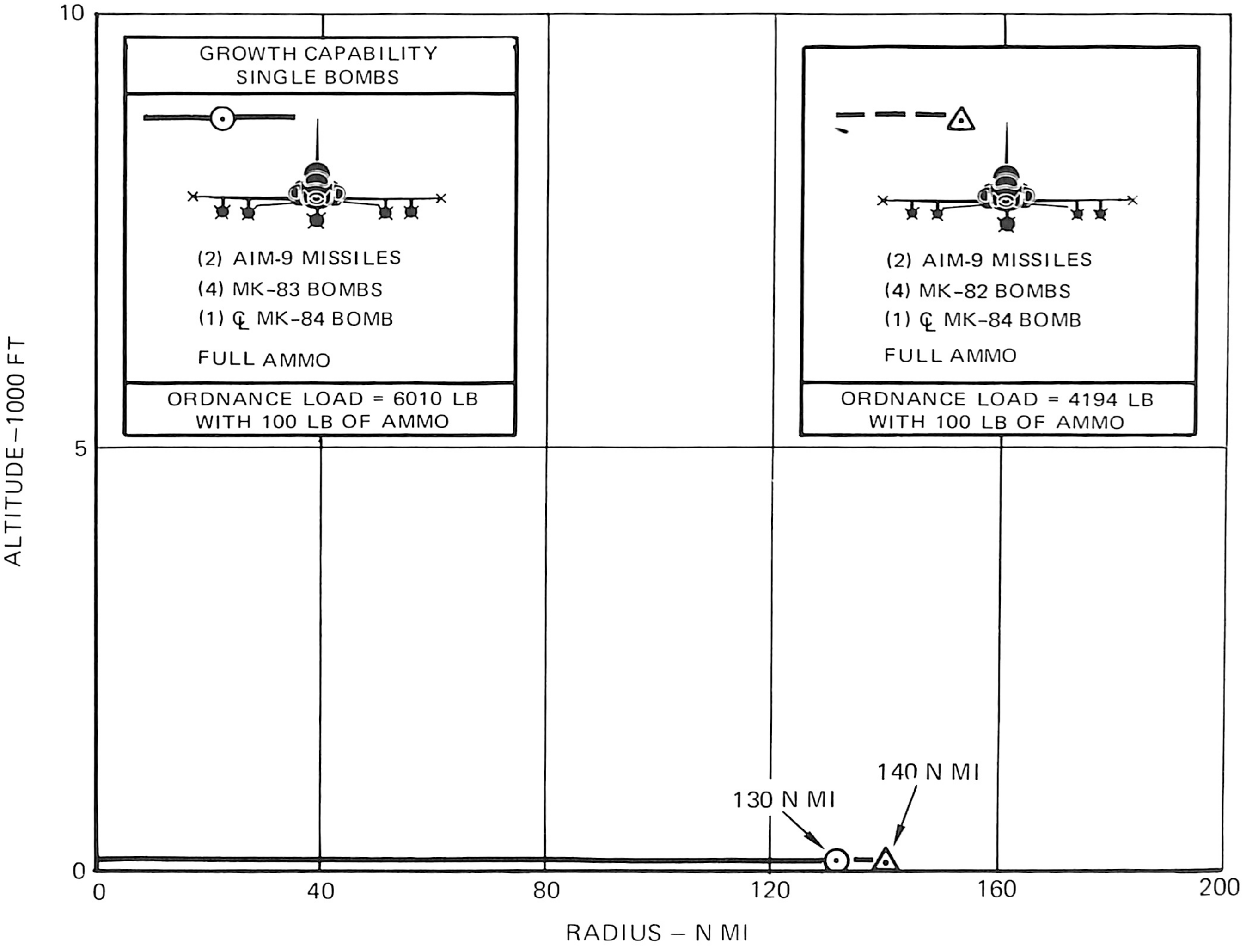
2 OPTIMUM CRUISE AT SEA LEVEL.

3 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO. MISSILES RETAINED.

4 OPTIMUM CRUISE AT SEA LEVEL.

5 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.

FIGURE 2-28. F-5E INTERDICTION MISSION (LO-LO-LO) (MAX BOMB LOAD)



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER. MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS. THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT.

2 OPTIMUM CRUISE AT SEA LEVEL.

3 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO. MISSILES RETAINED.

4 OPTIMUM CRUISE AT SEA LEVEL.

5 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.

FIGURE 2-29. F-5F INTERDICTION MISSION (LO-LO-LO) (MAX BOMB LOAD)

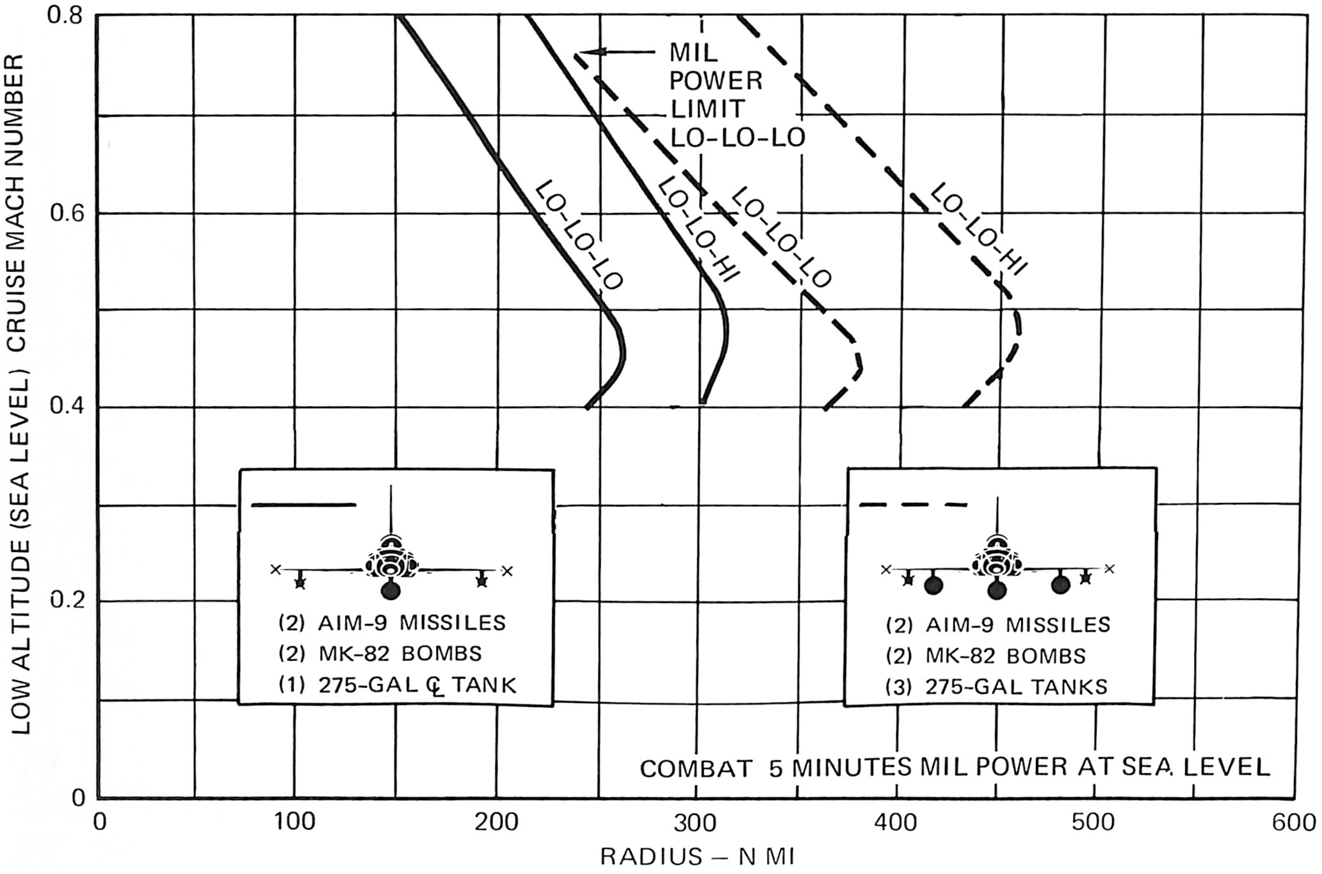


FIGURE 2-30. F-5E EFFECT OF LOW ALTITUDE (SEA LEVEL) CRUISE MACH NUMBER ON INTERDICTION MISSION RADIUS (LO-LO-HI AND LO-LO-LO)

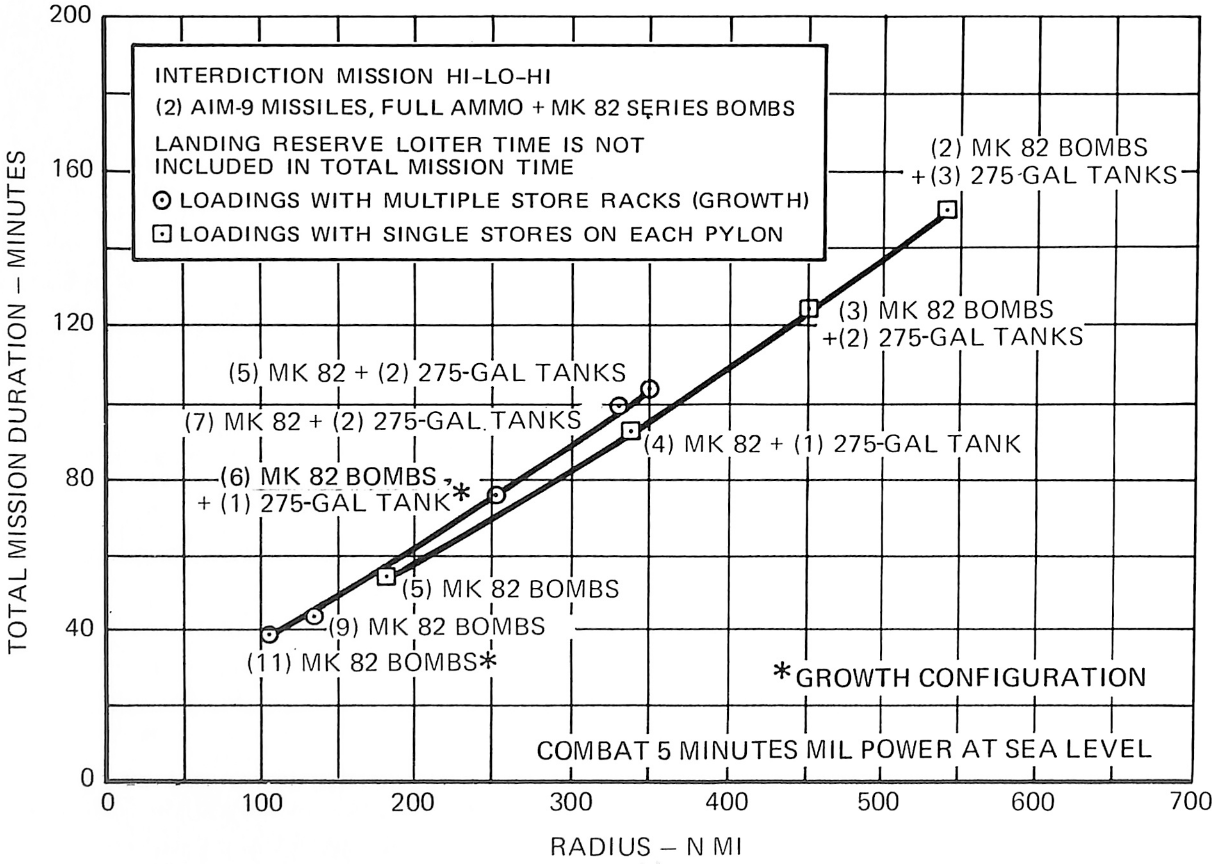


FIGURE 2-31. F-5E INTERDICTION MISSION DURATION VS RADIUS (HI-LO-HI)

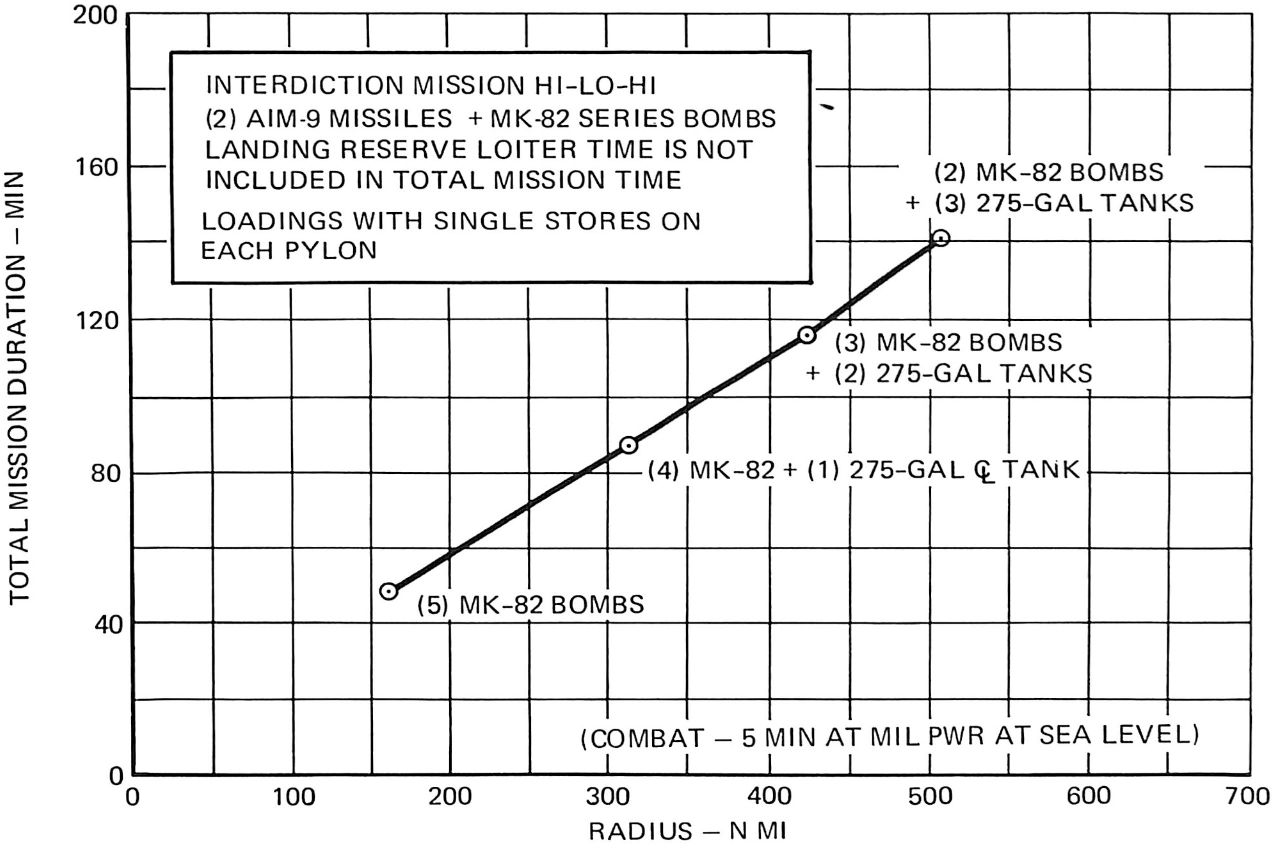


FIGURE 2-32. F-5F INTERDICTION MISSION DURATION VS RADIUS (HI-LO-HI)

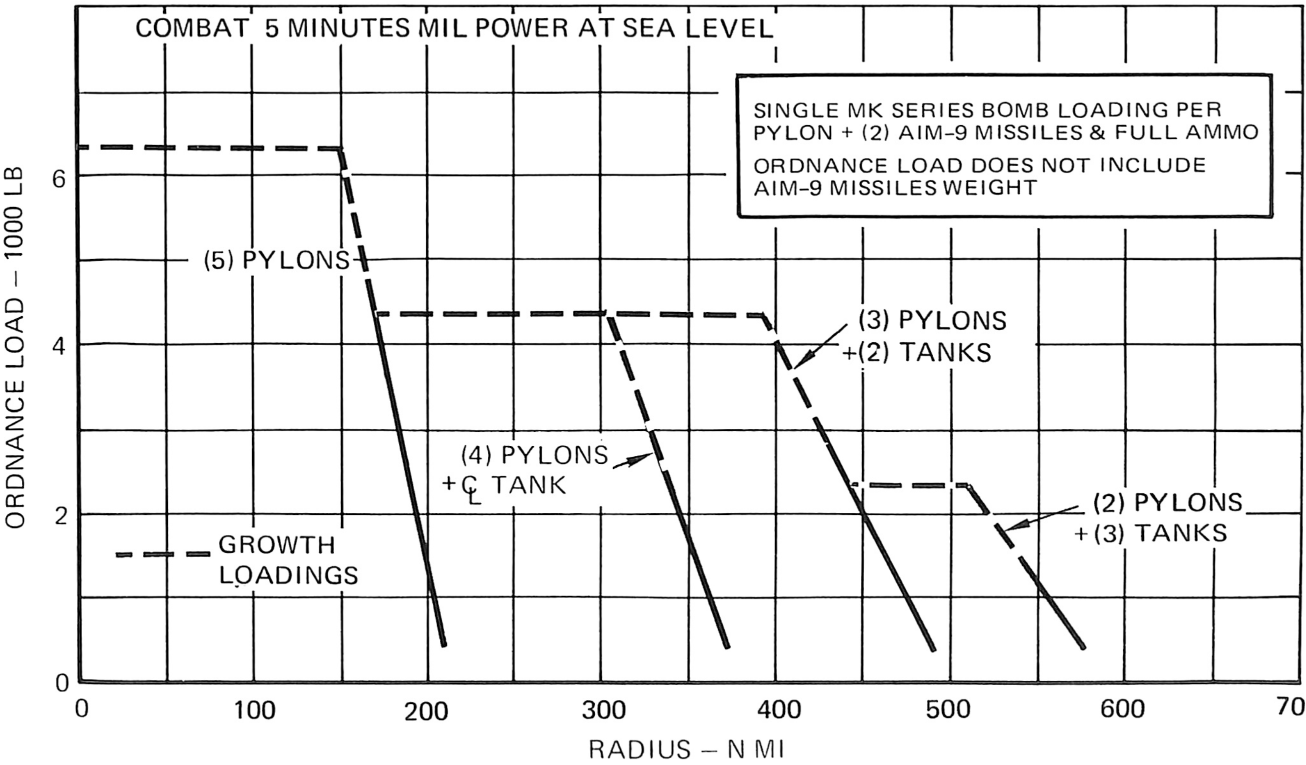


FIGURE 2-33. F-5E INTERDICTION MISSION (HI-LO-HI) ORDNANCE LOAD VS RADIUS – SINGLE MK SERIES BOMB LOADINGS PER PYLON

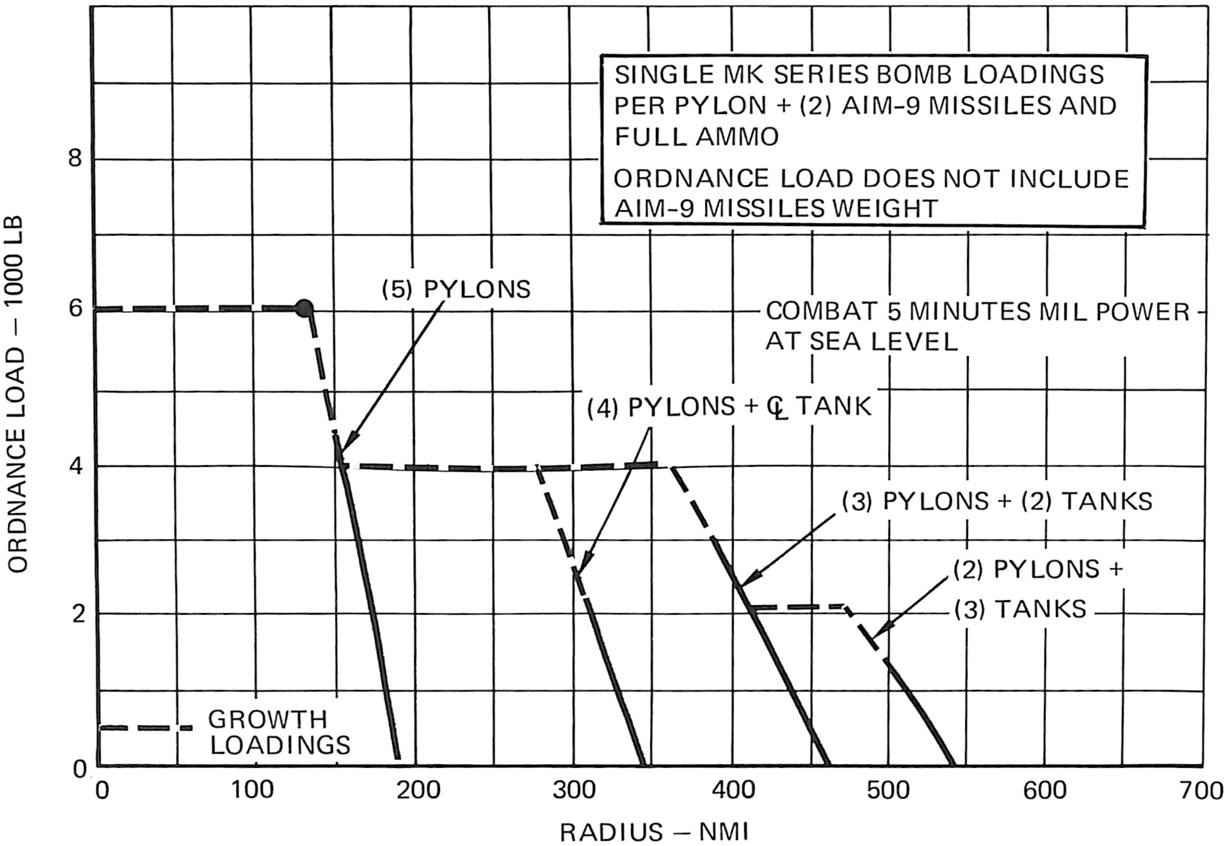


FIGURE 2-34. F-5F INTERDICTION MISSION (HI-LO-HI) ORDNANCE LOAD VS RADIUS – SINGLE MK SERIES BOMB LOADINGS PER PYLON

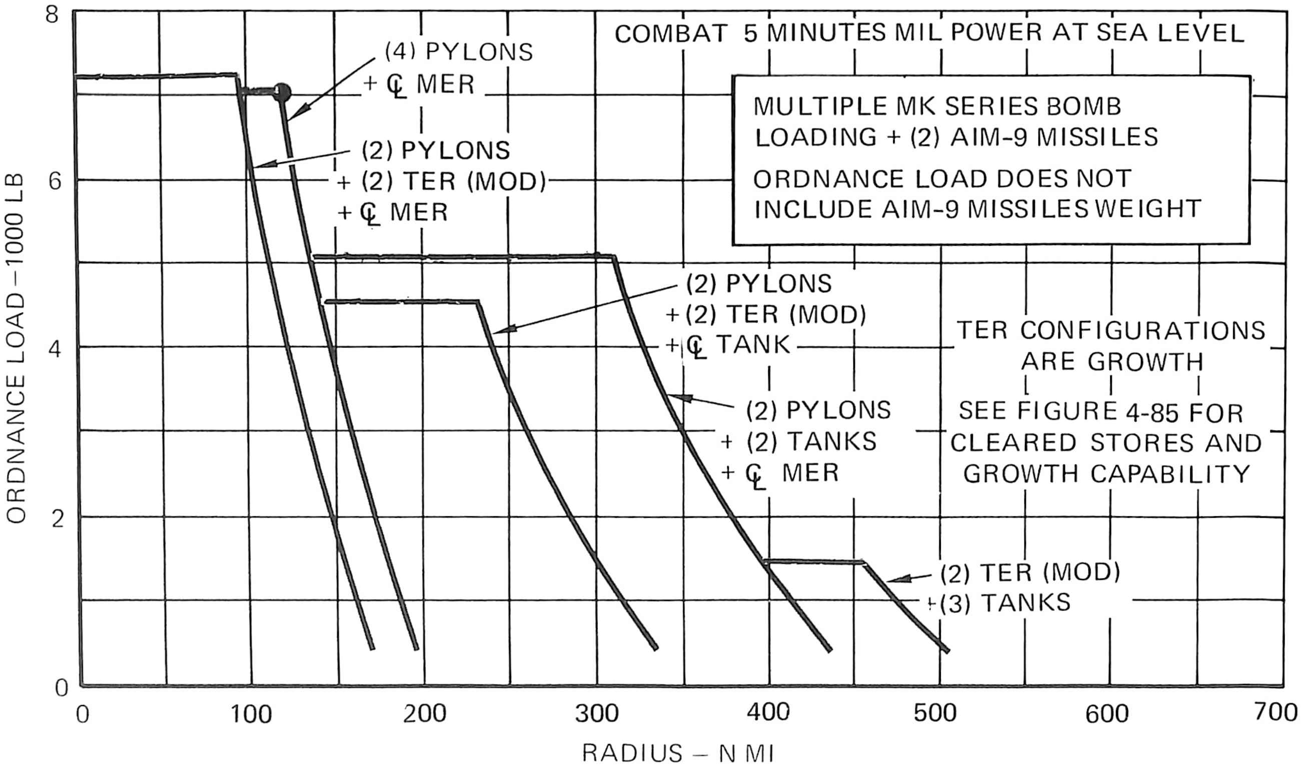


FIGURE 2-35. F-5E INTERDICTION MISSION (HI-LO-HI) ORDNANCE LOAD VS RADIUS – MULTIPLE MK SERIES BOMB LOADINGS PER PYLON

## Close Air Support Mission

Combat radius as a function of close air support mission loiter time prior to combat is presented in Figures 2-36 for the F-5E and Figure 2-37 for the F-5F for single MK-82, 500-pound-class bomb configurations. Figure 2-38 presents similar performance for the F-5E when the MK-82 bombs are grouped on MER or TER racks.

Figure 2-39 shows the variation of total mission time with precombat loiter times for single MK-82 500-pound bombs for the close air support mission for both the F-5E and F-5F aircraft.

Figure 2-40 presents the variation of total mission time with precombat loiter times for multiple grouped MK-82 bomb loadings for the F-5E airplane.

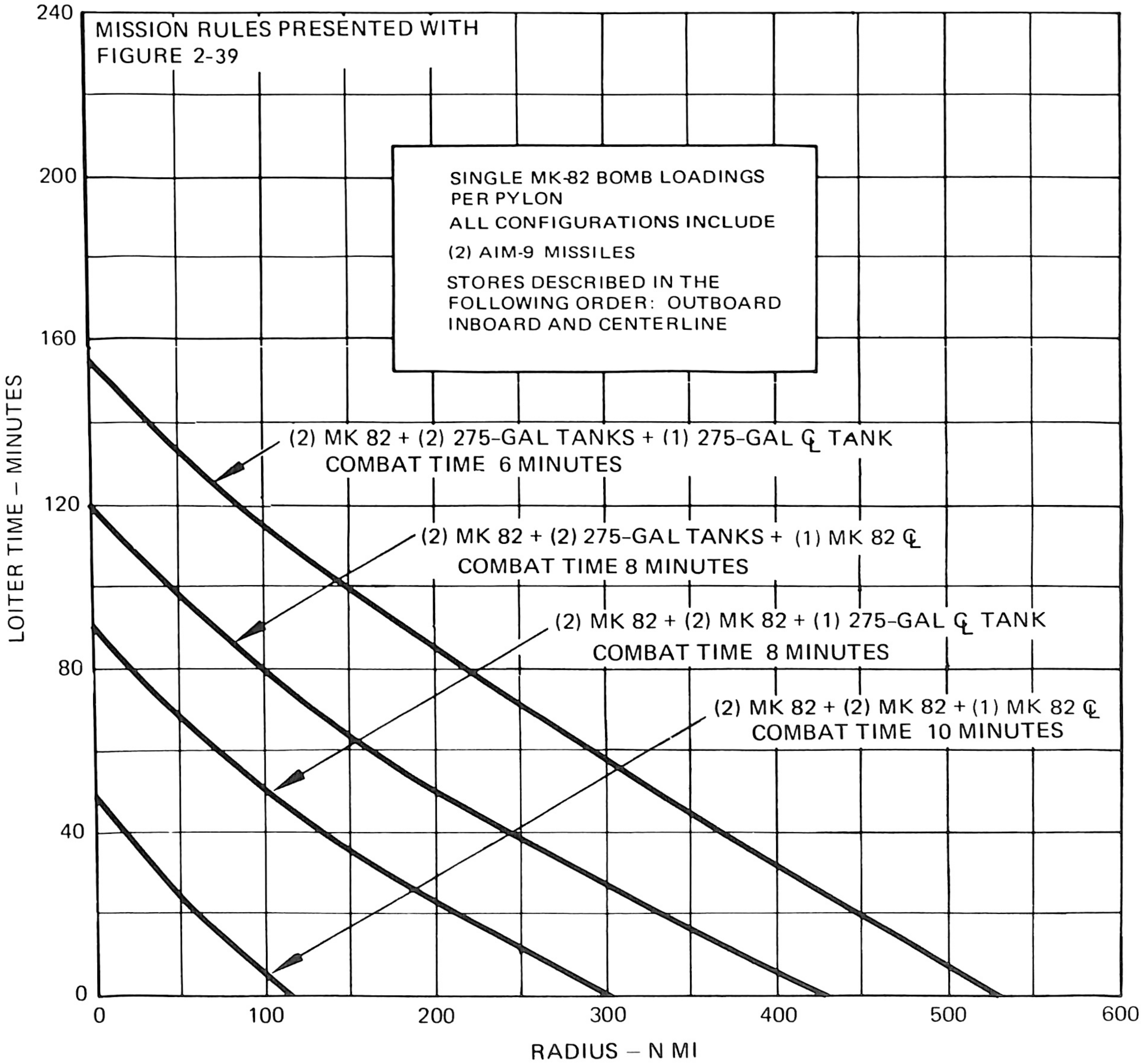


FIGURE 2-36. F-5E CLOSE AIR SUPPORT MISSION LOITER TIME VS COMBAT RADIUS (SINGLE MK-82 BOMB LOADINGS PER PYLON)

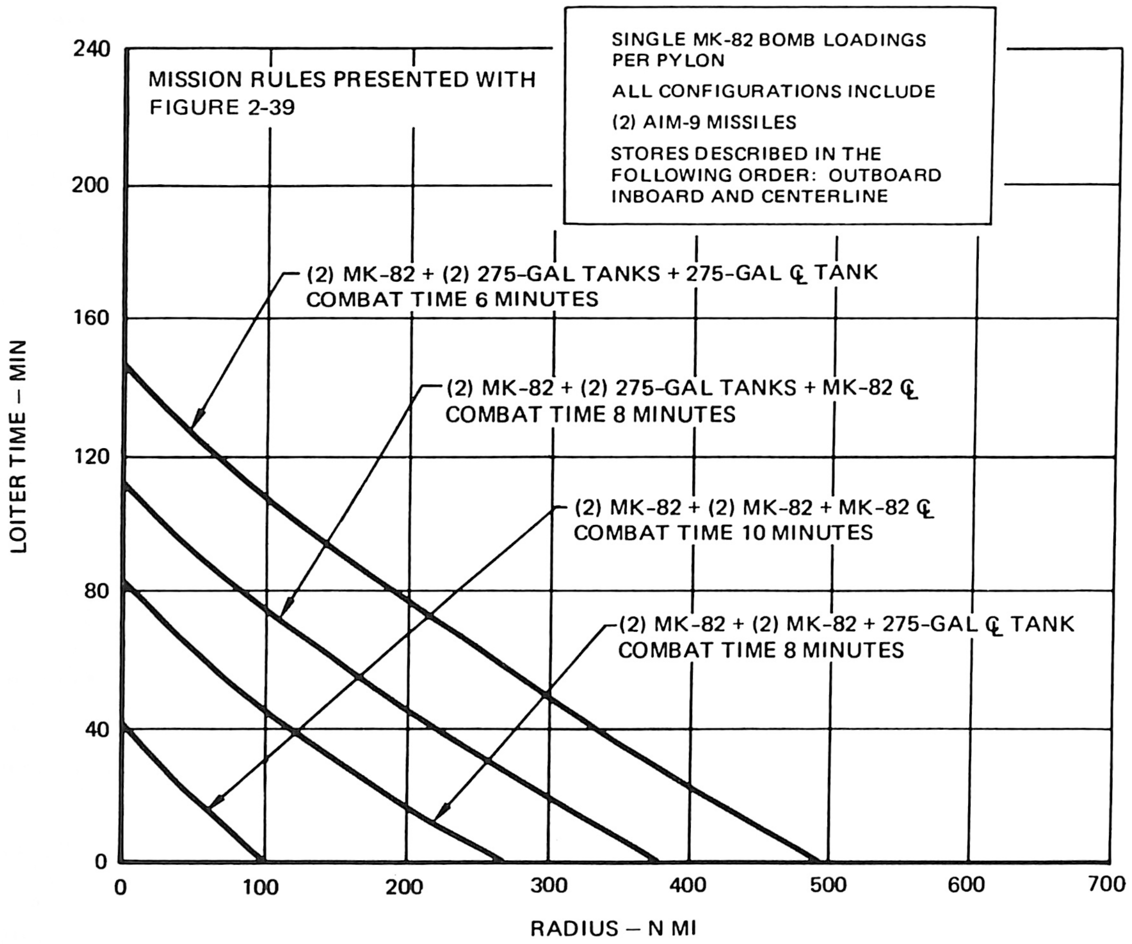


FIGURE 2-37. F-5F CLOSE AIR SUPPORT MISSION LOITER TIME VS COMBAT RADIUS (SINGLE MK-82 BOMB LOADINGS PER PYLON)

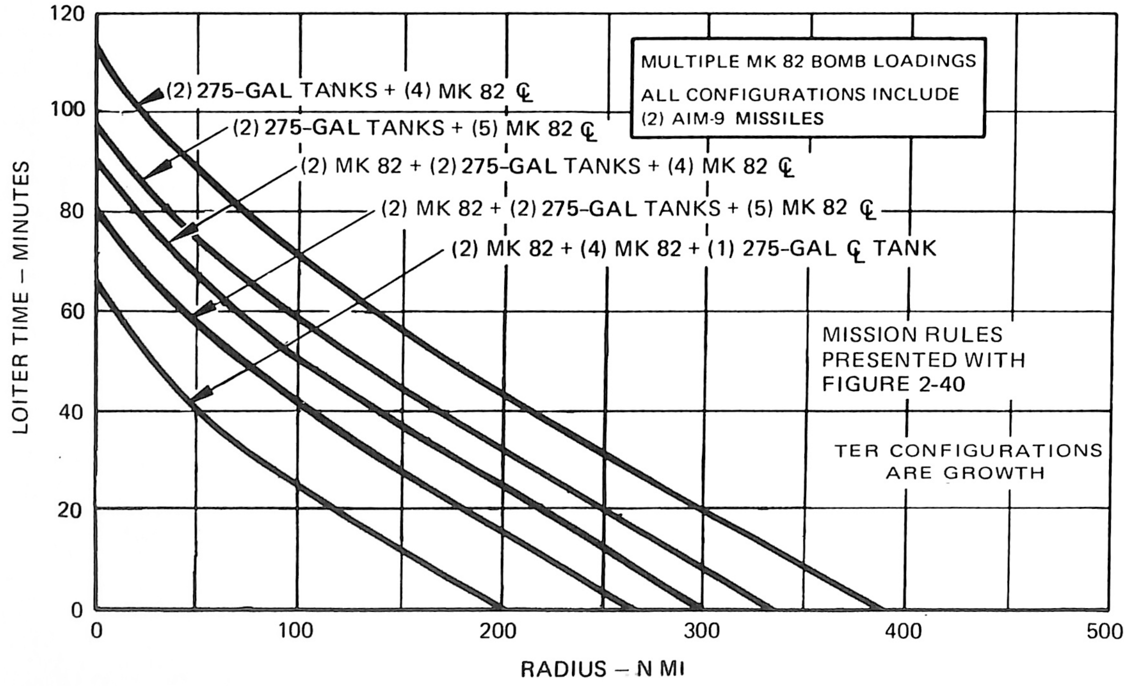
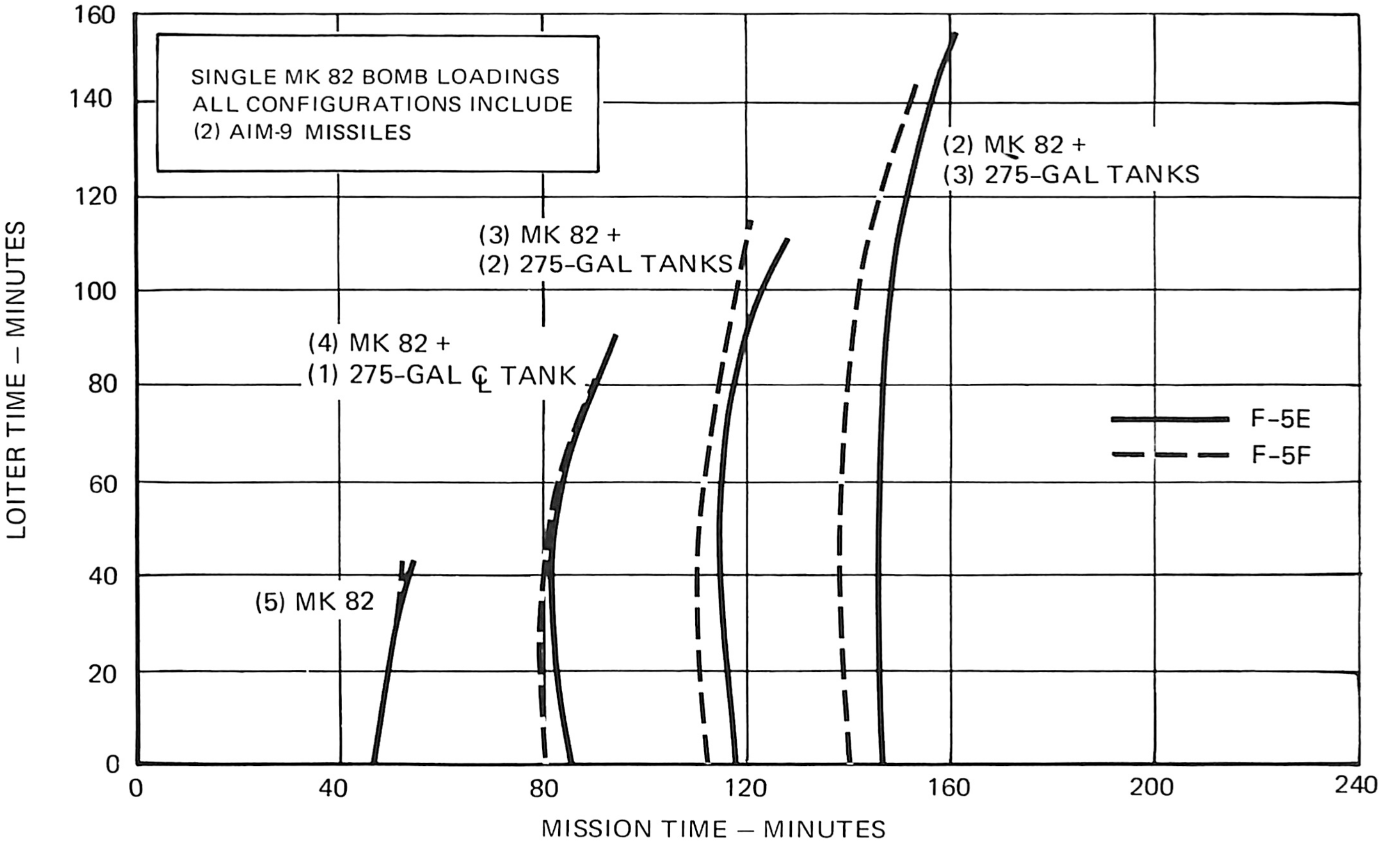


FIGURE 2-38. F-5E CLOSE AIR SUPPORT MISSION LOITER TIME VS COMBAT RADIUS (MULTIPLE MK-82 BOMB LOADINGS)



MISSION RULES

1 TAKEOFF ALLOWANCE: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT

2 MILITARY POWER CLIMB

3 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

4 DESCENT: TO SEA LEVEL, NO FUEL, TIME OR DISTANCE CREDIT

5 LOITER: MAXIMUM ENDURANCE AT SEA LEVEL

6 COMBAT: MILITARY POWER COMBAT AT SEA LEVEL AT 0.7 MACH NUMBER IN ACCORDANCE WITH FOLLOWING TABLE WHICH INCLUDES 4 MINUTES FOR GUN FIRING PLUS TIME FOR AIR-TO-GROUND ORDNANCE DELIVERY

| NO. BOMBS | COMBAT TIME (MINUTES) |
|---|---|
| 1 or 2 | 6 |
| 3 or 4 | 8 |
| 5 or 6 | 10 |

7 MILITARY POWER CLIMB

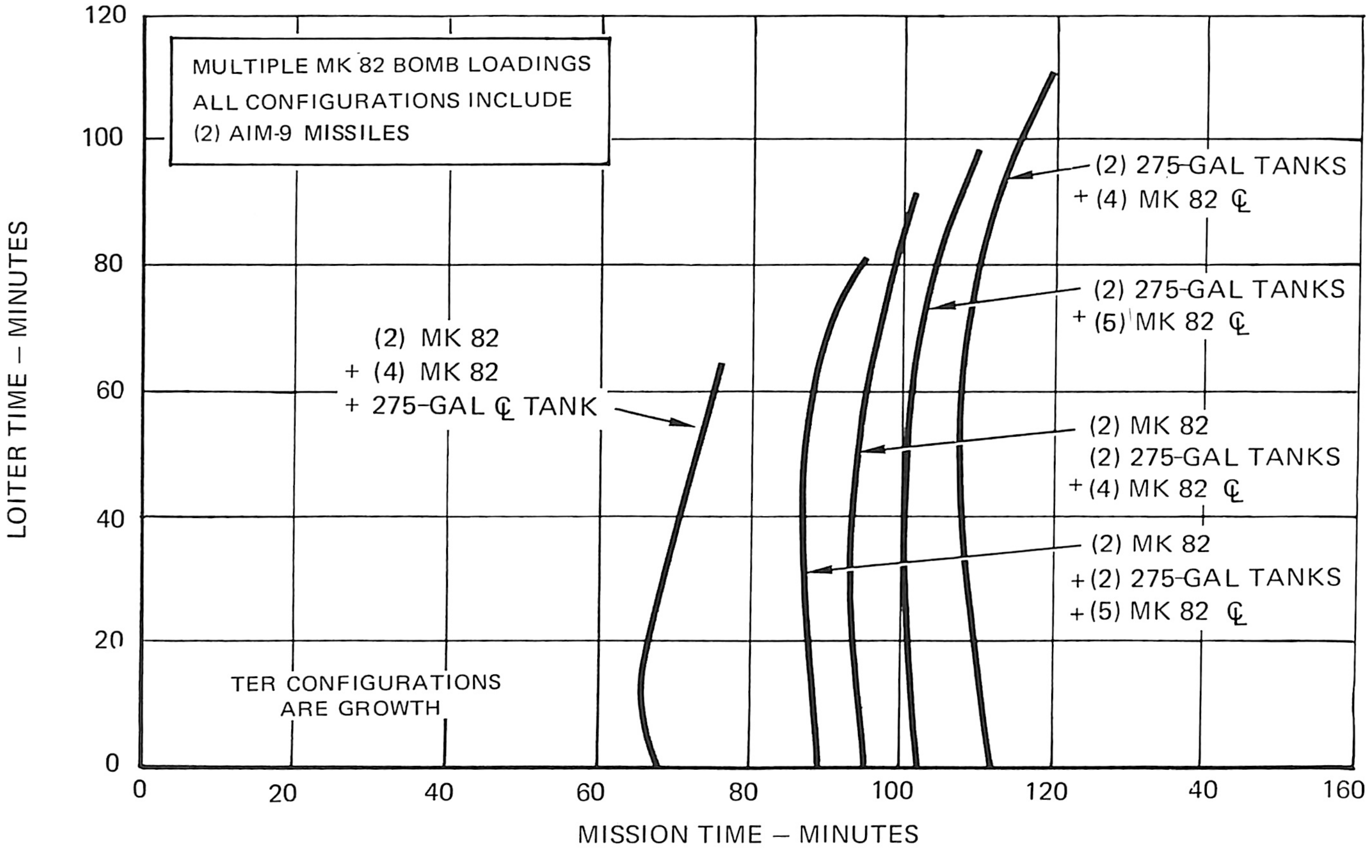
8 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE

9 DESCENT: TO SEA LEVEL, NO FUEL, TIME OR DISTANCE CREDIT

10 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE SEA LEVEL

11 TANKS, PYLONS, AND MISSILES ARE RETAINED

FIGURE 2-39. F-5E/F CLOSE AIR SUPPORT LOITER TIME VS MISSION TIME (SINGLE MK-82 LOADINGS)



MISSION RULES

1. TAKEOFF ALLOWANCE: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT
2. MILITARY POWER CLIMB
3. OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION
4. DESCENT: TO SEA LEVEL, NO FUEL, TIME OR DISTANCE CREDIT
5. LOITER: MAXIMUM ENDURANCE AT SEA LEVEL
6. COMBAT: MILITARY POWER COMBAT AT SEA LEVEL AT 0.7 MACH NUMBER IN ACCORDANCE WITH THE FOLLOWING TABLE WHICH INCLUDES 4 MINUTES FOR GUN FIRING PLUS TIME FOR AIR-TO-GROUND ORDNANCE DELIVERY

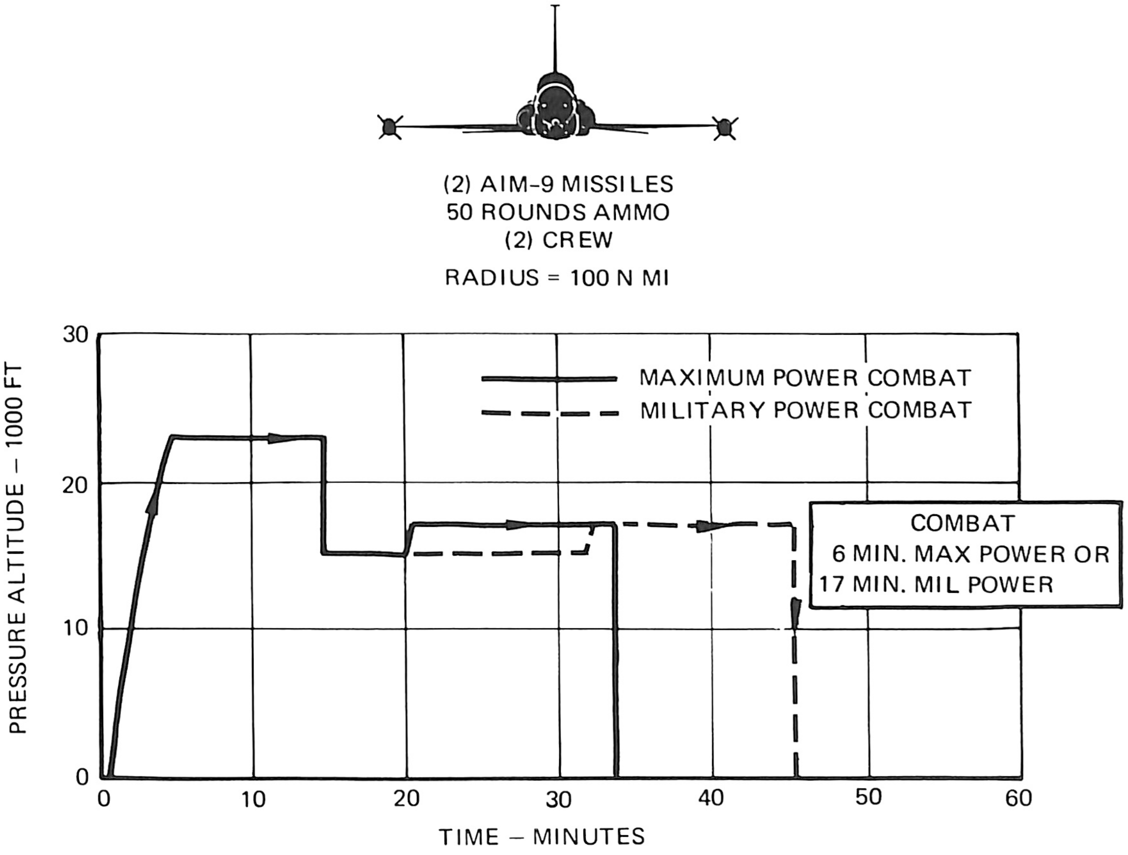
| NUMBER BOMBS | COMBAT TIME (MINUTES) | NUMBER BOMBS | COMBAT TIME (MINUTES) |
|---|---|---|---|
| 1 OR 2 | 6 | 5 OR 6 | 10 |
| 3 OR 4 | 8 | 7 OR 8 | 12 |

7. MILITARY POWER CLIMB
8. OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE
9. DESCENT: TO SEA LEVEL, NO FUEL, TIME OR DISTANCE CREDIT
10. LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE SEA LEVEL
11. TANKS, PYLONS, AND MISSILES ARE RETAINED

FIGURE 2-40. F-5E CLOSE AIR SUPPORT LOITER TIME VS MISSION TIME (MULTIPLE MK-82 LOADINGS)

## Training Missions

Two types of training missions are presented for the F-5F, each with a two-man crew and 50 rounds of ammunition (normal training practice). The Air Combat Maneuvering Training Mission, Figure 2-41, demonstrates the airplane's capabilities when used to give future fighter pilots indoctrination and experience in the realm of



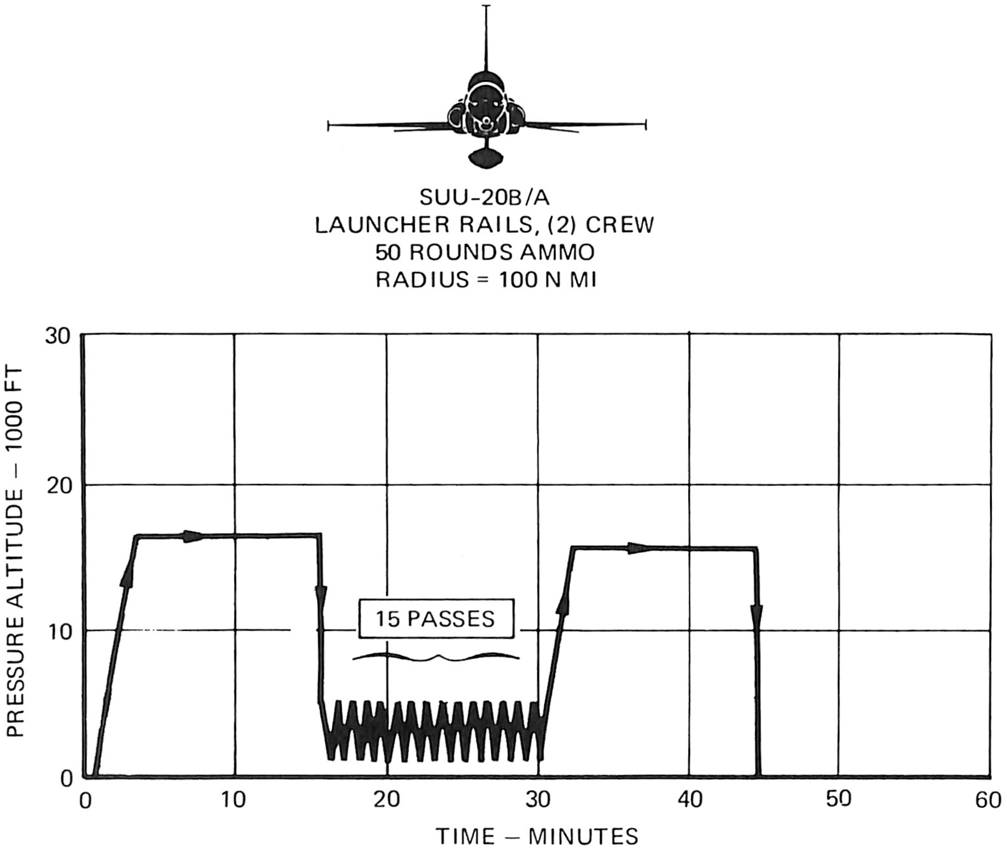
**MISSION RULES**

1. TAKEOFF ALLOWANCE: FUEL USED FOR 15 MINUTES AT TAXI POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KIAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED, NO DISTANCE CREDIT.
2. MILITARY POWER CLIMB TO 8000 FEET WHILE TURNING THROUGH 270°.
3. MILITARY POWER CLIMB ON COURSE FROM 8000 FEET TO 23,000 FEET.
4. CRUISE AT 23,000 FEET AT 350 KIAS TO TRAINING AREA 100 N MI FROM BASE.
5. DESCEND TO 15,000 FEET, NO CREDIT FOR TIME, FUEL OR DISTANCE.
6. COMBAT: 15,000 FEET AT 0.8 MACH NUMBER FOR MAX AVAILABLE TIME NOTED AT MAXIMUM POWER OR AT MILITARY POWER DEPENDING ON MISSION.
7. MILITARY POWER CLIMB FROM 15,000 FEET TO 17,000 FEET.
8. CRUISE AT 17,000 FEET AT 350 KIAS TO POINT OVER BASE.
9. DESCEND TO BASE, NO CREDIT FOR TIME, FUEL OR DISTANCE.
10. LANDING RESERVE: 900 POUNDS OF FUEL OVER BASE.

NOTES:
1. ENROUTE TRAFFIC CONTROL PROCEDURES AND 270° TURNING DESCENT CONSIDERED IN CHOICE OF LANDING RESERVE.
2. REPRESENTATIVE OF TYPICAL WILLIAMS AFB TRAINING MISSION.

FIGURE 2-41. F-5F AIR COMBAT MANEUVERING TRAINING MISSION

air-to-air combat. The Air-to-Ground Training Mission, Figure 2-42, demonstrates the airplane's capabilities when used to indoctrinate pilots in ground attack mission techniques. The mission rules presented on the figures were suggested by the syllabus, traffic patterns, and allowances used at Williams Air Force Base 425th Tactical Training Squadron. The training area for both missions is 100 n.mi. from the base.



MISSION RULES

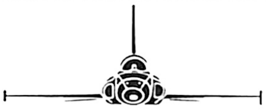
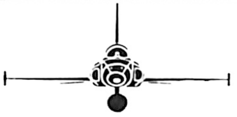
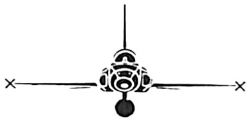
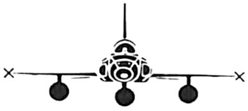
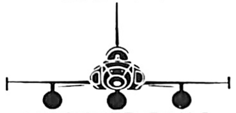
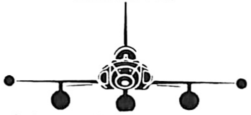
1. TAKEOFF ALLOWANCES: FUEL USED FOR 15 MINUTES AT TAXI POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KIAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT.
2. MILITARY POWER CLIMB TO 8,000 FEET WHILE TURNING THROUGH 270°, NO DISTANCE CREDIT.
3. MILITARY POWER CLIMB ON COURSE FROM 8,000 FEET TO 16,500 FEET.
4. CRUISE AT 16,500 FEET AT 350 KIAS TO TRAINING AREA 100 NAUTICAL MILES FROM BASE.
5. DESCEND TO 3,000 FEET, NO CREDIT FOR TIME, FUEL OR DISTANCE.
6. STORE DELIVERY FUEL ALLOWANCE: FUEL USED AT 5,000 FEET AT 0.6 MACH NUMBER AND 96% RPM AT THE RATE OF ONE MINUTE PER PASS.
7. MILITARY POWER CLIMB FROM 5,000 FEET TO 15,500 FEET.
8. CRUISE AT 15,500 FEET AT 350 KIAS TO POINT OVER BASE.
9. DESCEND TO BASE, NO CREDIT FOR TIME, FUEL OR DISTANCE.
10. LANDING RESERVE: 900 POUNDS OF FUEL OVER BASE.

NOTES:
1. ENROUTE TRAFFIC CONTROL PROCEDURES AND 270° TURNING DESCENT CONSIDERED IN CHOICE OF LANDING RESERVE.
2. REPRESENTATIVE OF TYPICAL WILLIAMS AFB TRAINING MISSION.

FIGURE 2-42. F-5F AIR-TO-GROUND TRAINING MISSION

## Ferry Missions

The ferry missions shown in Figure 2-43 demonstrate the maximum distances that the F-5E/F airplanes can be flown between any two bases. F-5F ferry missions are flown with a crew of one. Neither ammunition nor links are carried on the ferry missions for either airplane.

| CONFIGURATION | F-5E RANGE N MI | | F-5F RANGE N MI | |
|---|---|---|---|---|
| | TANKS RETAINED | TANKS DROPPED | TANKS RETAINED | TANKS DROPPED |
| <br>LAUNCHER RAILS | 960 | — | 925 | — |
| <br>LAUNCHER RAILS<br>(1) 275-GAL ℄ TANK | 1315 | 1395 | 1240 | 1310 |
| <br>(2) AIM-9 MISSILES<br>(1) 275-GAL ℄ TANK | 1220 | 1295 | 1145 | 1220 |
| <br>(2) AIM-9 MISSILES<br>(3) 275-GAL TANKS | 1555 | 1755 | 1455 | 1650 |
| (GROWTH)<br><br>LAUNCHER RAILS<br>(3) 275-GAL TANKS | 1635 | 1870 | 1540 | 1760 |
| (GROWTH)<br><br>(2) 50-GAL TIP TANKS<br>(3) 275-GAL TANKS | 1685 | 1925 | — | — |

**MISSION RULES**

1. TAKEOFF ALLOWANCE: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KIAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT
2. MILITARY POWER CLIMB
3. OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION
4. DESCENT: NO FUEL, TIME OR DISTANCE CREDIT
5. LANDING RESERVE: FUEL FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL
6. PYLONS RETAINED, TANKS RETAINED OR DROPPED WHEN EMPTY AS NOTED

FIGURE 2-43. FERRY MISSIONS

## PERFORMANCE WITH JET A-1 FUEL

The F-5E/F airplanes were designed to operate on JP-4 (NATO F-40) fuel, U.S. Military Specification MIL-J-5624. They may also be operated on commercial Jet A-1 fuel with icing inhibitor (Jet A-1 with FSII). The use of Jet A-1 will produce slight changes in the engine starting characteristics, the airstart envelope, and the afterburner relight envelope. However, flight and laboratory testing has demonstrated that use of Jet A-1 fuel will not adversely affect aircraft reliability, the maintenance index, or the service life of engines or aircraft.

Because of the increased average density of Jet A-1 fuel (6.7 pound/gallon versus 6.5 pound/gallon for JP-4), full-fuel takeoff weights will increase by as much as 300 pounds with some slight decremental effects on takeoff distances and initial climb rates. However, because the energy value per pound of Jet A-1 is approximately the same as JP-4 and because more pounds of fuel can be carried, aircraft range and radius are increased.

Table 2-3 presents the F-5E point performance summary comparison for JP-4 and Jet A-1 fuel. The maximum-weight takeoff ground run increases by 125 feet, the sea level maximum rate of climb is decreased by 250 feet/minute, and the combat ceiling is reduced by 200 feet.

### TABLE 2-3. F-5E POINT PERFORMANCE SUMMARY COMPARISON

| | | FUEL | |
|---|---|---|---|
| | | JP-4 | JET A-1 |
| TAKEOFF GROSS WEIGHT | | | |
| CLEAN WITH RAILS | LB | 15,292 | 15,431 |
| MAX WEIGHT WITH AIM-9 MISSILES | LB | 24,018 | 24,318 |
| TAKEOFF GROUND RUN | | | |
| CLEAN WITH RAILS | FT | 1,800 | 1,825 |
| AT MAX WEIGHT WITH AIM-9 MISSILES | FT | 5,100 | 5,225 |
| COMBAT WEIGHT WITH RAILS (50% FUEL) | LB | 13,092 | 13,163 |
| RATE OF CLIMB (SEA LEVEL) | FT/MIN | 33,500 | 33,250 |
| MAXIMUM SPEED (36,089 FEET) | MACH | 1.6 | 1.6 |
| COMBAT CEILING | FT | 52,500 | 52,300 |

## PERFORMANCE WITH JET A-1 FUEL

The F-5E/F airplanes were designed to operate on JP-4 (NATO F-40) fuel, U.S. Military Specification MIL-J-5624. They may also be operated on commercial Jet A-1 fuel with icing inhibitor (Jet A-1 with FSII). The use of Jet A-1 will produce slight changes in the engine starting characteristics, the airstart envelope, and the afterburner relight envelope. However, flight and laboratory testing has demonstrated that use of Jet A-1 fuel will not adversely affect aircraft reliability, the maintenance index, or the service life of engines or aircraft.

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| TAKEOFF GROSS WEIGHT | | | |
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| TAKEOFF GROUND RUN | | | |
| CLEAN WITH RAILS | FT | 1,800 | 1,825 |
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| MAXIMUM SPEED (36,089 FEET) | MACH | 1.6 | 1.6 |
| COMBAT CEILING | FT | 52,500 | 52,300 |

Table 2-4 presents a comparison of the F-5E mission performance using JP-4 and Jet A-1 fuel. Noticeable improvements in mission range and radius can be seen. The combat air patrol mission radius with three tanks is increased from 680 to 715 nautical miles. The HI-LO-HI interdiction mission radius with four bombs is increased from 355 nautical miles to 370 nautical miles and the ferry range with three tanks and AIM-9 missiles (tanks dropped when empty) increases from 1755 nautical miles with JP-4 to 1805 nautical miles with Jet A-1, an improvement of 50 nautical miles. These increases are indicative of the overall mission performance improvement with Jet A-1 fuel and the same approximate percentage increases can be expected for other F-5E/F missions.

Table 2-9 presents the F-5E/F weight summaries with Jet A-1 fuel.

TABLE 2-4. F-5E MISSION PERFORMANCE SUMMARY COMPARISON

| | FUEL | |
|---|---|---|
| | JP-4 | JET A-1 |
| COMBAT AIR PATROL (5 MINUTES COMBAT AT 15,000 FEET AT 0.8 MACH) | | |
| (2) AIM-9 + (3) 275-GALLON TANKS | 680 N MI | 715 N MI |
| COMBAT AIR PATROL (5 MINUTES COMBAT AT 15,000 FEET AT 0.8 MACH) | | |
| (2) AIM-9 + (1) 275-GALLON ℄ TANK | 410 N MI | 435 N MI |
| INTERDICTION | | |
| (4) MK-82 BOMBS + (1) 275-GALLON ℄ TANK (TANK DROPPED WHEN EMPTY) | | |
| HI-LO-HI | 355 N MI | 370 N MI |
| LO-LO-HI | 295 N MI | 310 N MI |
| LO-LO-LO | 250 N MI | 260 N MI |
| INTERDICTION | | |
| (2) MK 82 BOMBS + (3) 275-GALLON TANKS (TANKS DROPPED WHEN EMPTY) | | |
| HI-LO-HI | 615 N MI | 645 N MI |
| LO-LO-HI | 520 N MI | 535 N MI |
| LO-LO-LO | 420 N MI | 430 N MI |
| FERRY RANGE (2) AIM-9 + (3) 275-GALLON TANKS | | |
| TANKS RETAINED | 1,555 N MI | 1,600 N MI |
| TANKS DROPPED | 1,755 N MI | 1,805 N MI |

## AIR-TO-AIR COMBAT

Primary emphasis in the design of both the J85-GE-21 engine and the F-5E/F air vehicles was placed on optimizing air superiority fighter capability.

The maneuvering performance of the F-5E/F has been improved considerably over the F-5A/B by the additional engine thrust, increased leading edge extension (LEX) and maneuvering flaps. The increased fuel volume, fire control radar, lead-computing sight, and improved AIM-9 missiles also augment the airplane's air combat capabilities.

The F-5E/F retains the exceptional F-5A/B flying qualities that have enabled the basic F-5s to consistently defeat Mach 2 and other high performance fighter aircraft in air combat maneuvers, in both single and multiple airplane situations.

Engine inlets and ducts have been designed to favor the requirements of maneuvering flight. Minimum distortion of the airflow entering the engine is obtained by designing for low duct Mach numbers, incorporating duct boundary layer bleed, and the use of auxiliary inlets at low aircraft airspeeds. Efficient turning of the flow at high angles of attack is derived from the upper lip overhang and lip contours.

The J85-GE-21 engine design has been optimized to favor the maneuvering regime. A fast response temperature sensor improves engine response to rapid changes in flight condition; the main fuel control has been improved significantly, with the dynamic response of the engine control system increased by a factor of two. The propulsion system is highly responsive to power control demands during combat. Response time for throttle transients from 90 percent to maximum power is less than 2.0 seconds throughout the air battle arena.

The exit nozzle is hydraulically actuated to provide increased responsiveness during transients and better stall protection. Engine minimum nozzle area has been rescheduled to improve engine transient response at low airspeed.

Complete engine insensitivity to gun firing is obtained by using the same gun gas deflectors and relative gun-to-duct position as on the F-5A airplanes.

### Maneuvering Air Battle Arena

Experience together with analysis has defined a region where all fighters are forced to operate in order to attain their best maneuvering capability. This region is the primary combat region of the Maneuvering Air Battle Arena, Figure 2-44. The air battle arena includes the primary combat region and the transient high and low speed regions. These regions were derived from data obtained from a large number of actual fighter-to-fighter combat engagements, simulated combat maneuvers, and analytical evaluations of fighter aircraft maneuvering performance variation with Mach number. While air-to-air combat may begin anywhere in the flight envelope, victory depends on attaining a position of advantage over the enemy, and this in turn requires matching or exceeding his turn rate. Peak turn rates and minimum turn radii for both maximum lift and sustained turns occur in a relatively well-defined band centering around 0.8 Mach number for all fighter aircraft.

This turn performance variation with Mach number explains the fact that the major portion of the air battle takes place in the primary combat region, even in those cases where one or both of the combatants have Mach 2 capability. At supersonic speeds, even at maximum load factor, noticeably increased turn radii are required, due to fundamental mechanics of maneuvering flight with consequent lower turn rates, and a considerable maneuvering disadvantage. Even when contact is initiated at supersonic speeds, the abrupt maneuvering required to gain position or to maintain visual contact causes rapid deceleration into the primary combat region.

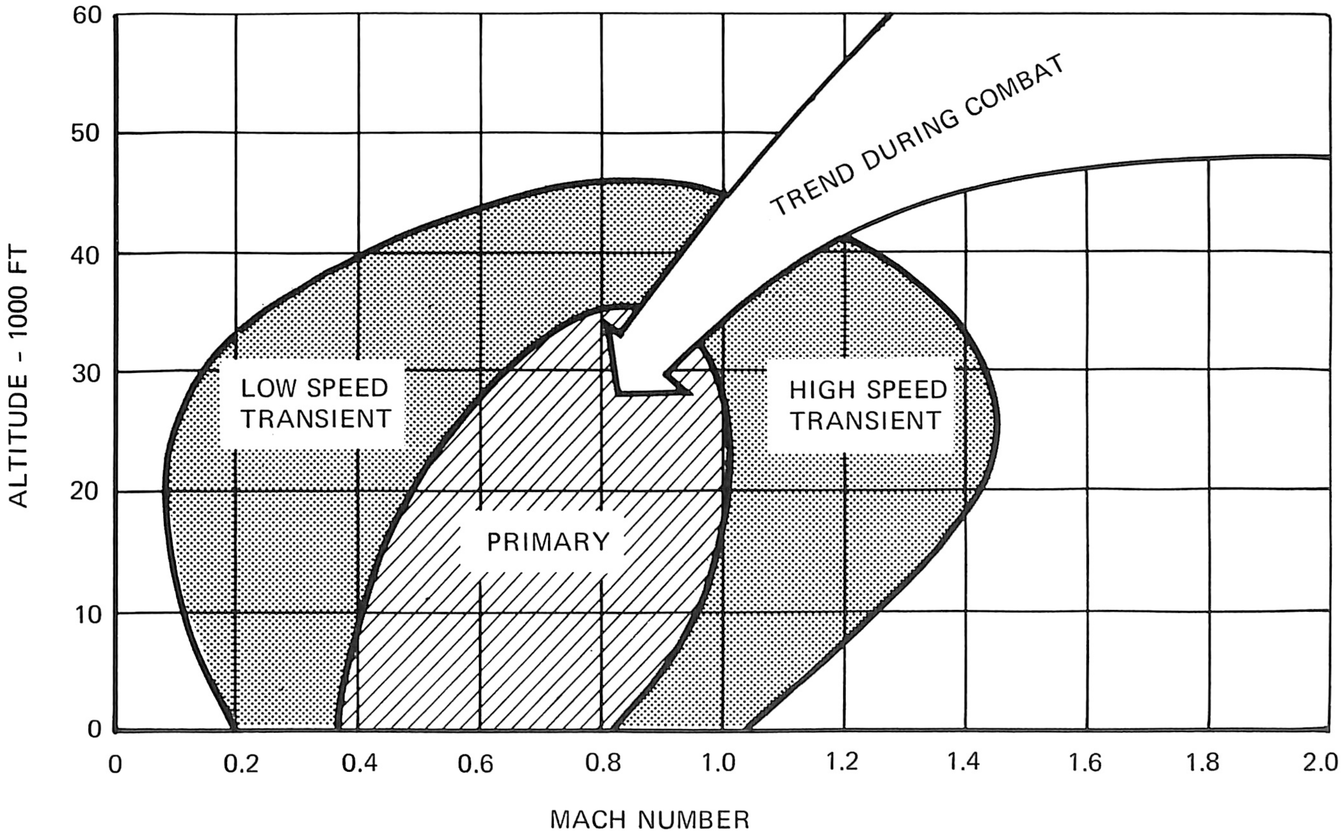


FIGURE 2-44. MANEUVERING AIR BATTLE ARENA

## Combat Maneuvering Performance

The F-5E mach/altitude envelope is superimposed on the air battle arena in Figure 2-45 and the F-5F in Figure 2-46. The F-5E/F operational envelopes fully encompass the air battle arena. The dive pullout curves allow for staying inside the 1700 PSF placard limit during a 4g pullout.

The F-5E manuevering performance is illustrated in Figures 2-47, 2-48 and 2-49, for altitudes of 5,000, 15,000 and 30,000 feet, respectively and the F-5F curves in Figures 2-50 through 2-52. Figure 2-47 shows that at 5,000 feet and 0.6 Mach number the F-5E has a sustained turn rate of 13.1 degrees per second with a 2850-foot turn radius at a load factor of 4.8g. The maximum lift turn rate for the F-5E at 5000 feet and 0.6 Mach number is 20.3 degrees per second and the turn radius is 1800 feet at the design limit load factor of 7.33g.

The instantaneous turn performance at maximum lift reflects the F-5E/F design emphasis on the hard-turn dogfight situation. These examples illustrate the design emphasis on optimizing F-5E/F maneuvering performance within the primary region of the air battle arena.

Specific Power versus Turn Rate data for the F-5E are plotted in Figures 2-53 and 2-54 and the F-5F in Figures 2-55 and 2-56. Specific power or more exactly specific excess power ($P_s$) is the aircraft's excess thrust multiplied by its true speed divided by airplane gross weight, or in equation form $P_s = F_x V/W$. Therefore, $P_s$ represents the ability of the aircraft to climb or to accelerate at a particular combination of turn rate or load factor, altitude and Mach number.

The $P_s$ advantage of one airplane over another at zero turn rate is a measure of its level flight "one g" acceleration advantage. The turn rate advantage of one airplane over another at zero $P_s$ is a measure of its ability to turn inside the other in steady-state maximum sustained turns for the specific altitude/Mach number condition. When an airplane's $P_s$ is equal to zero in a turn, thrust is just equal to drag (excess thrust is equal to zero) and the airplane is in a sustained steady-state turn. The $P_s$ and turn rate advantage of one aircraft over an adversary can be traded for acceleration or altitude gain, or it can be used to gain a position advantage.

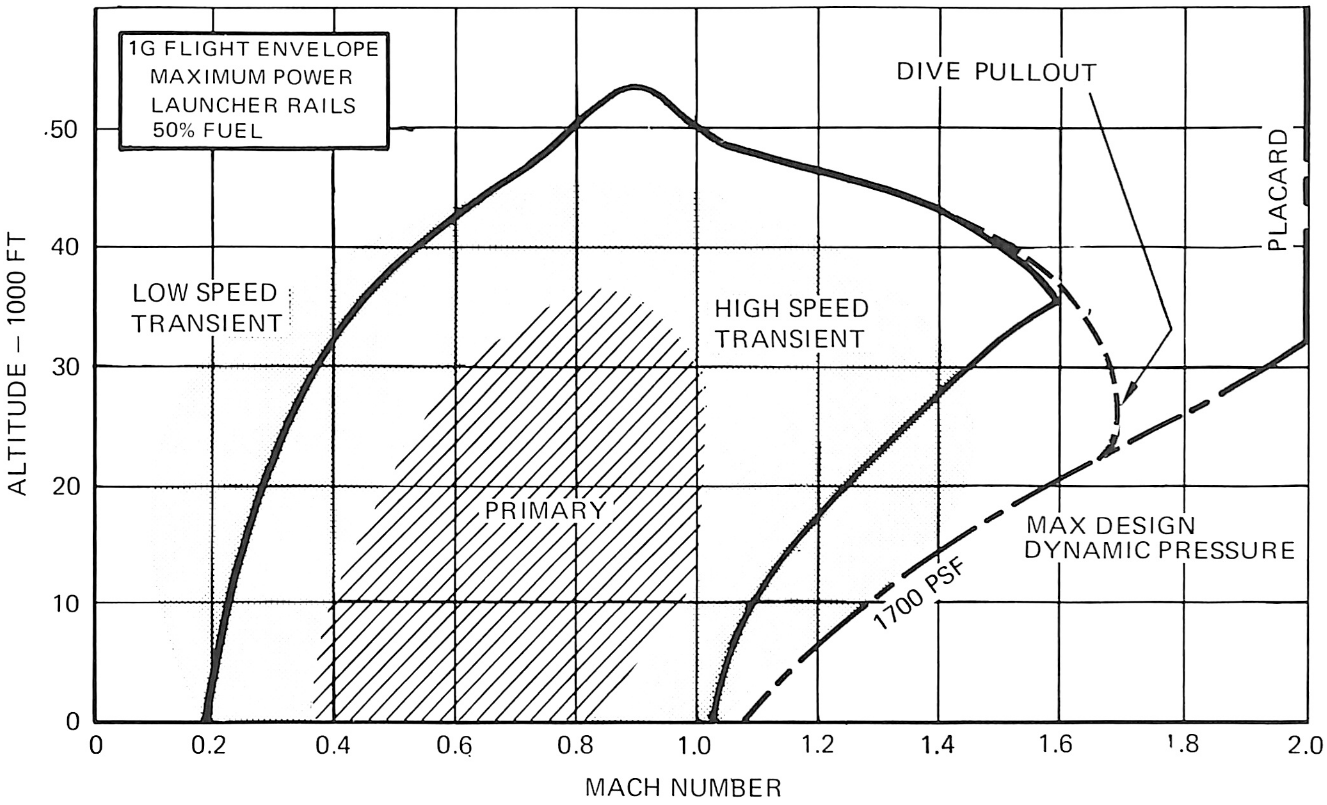


FIGURE 2-45. F-5E MACH/ALTITUDE SUMMARY AND AIR BATTLE ARENA

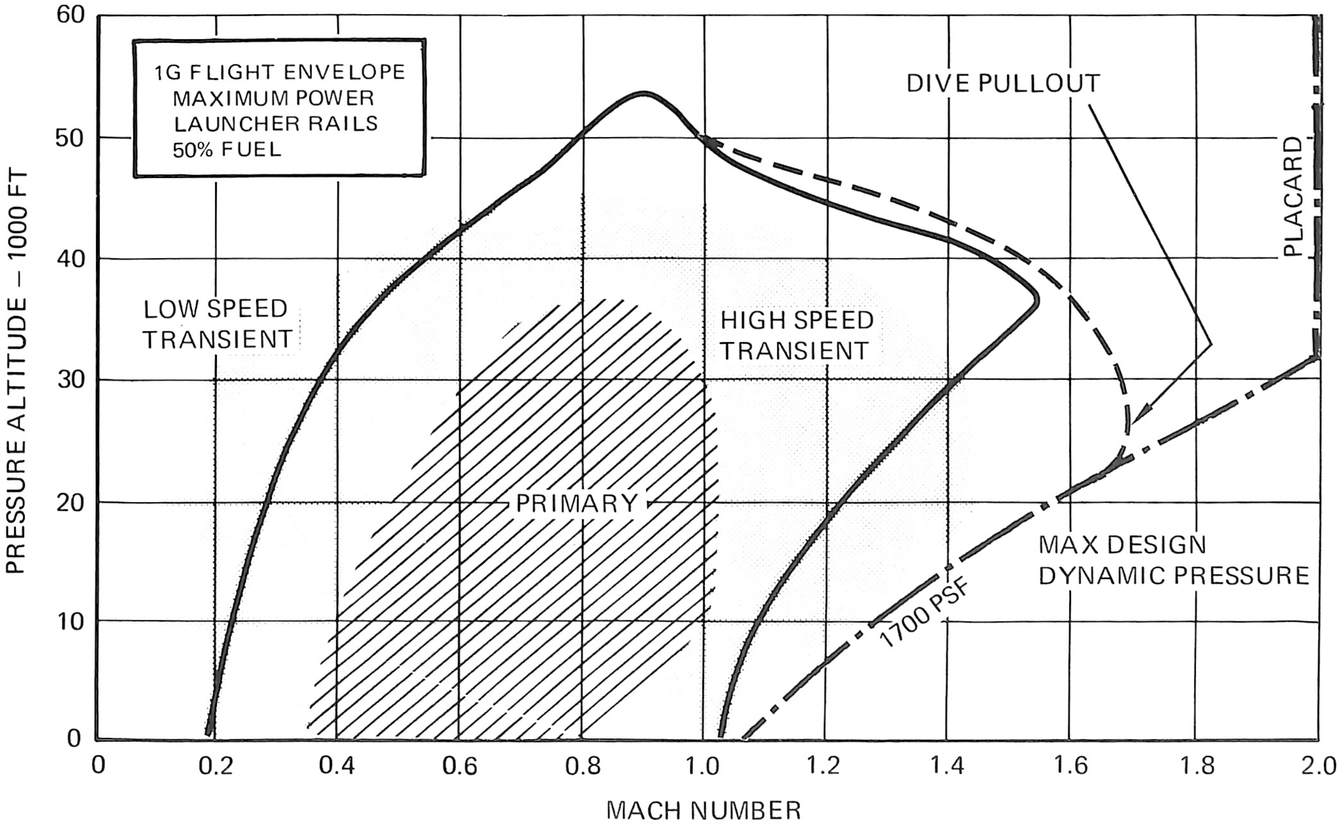


FIGURE 2-46. F-5F MACH/ALTITUDE SUMMARY AND AIR BATTLE ARENA

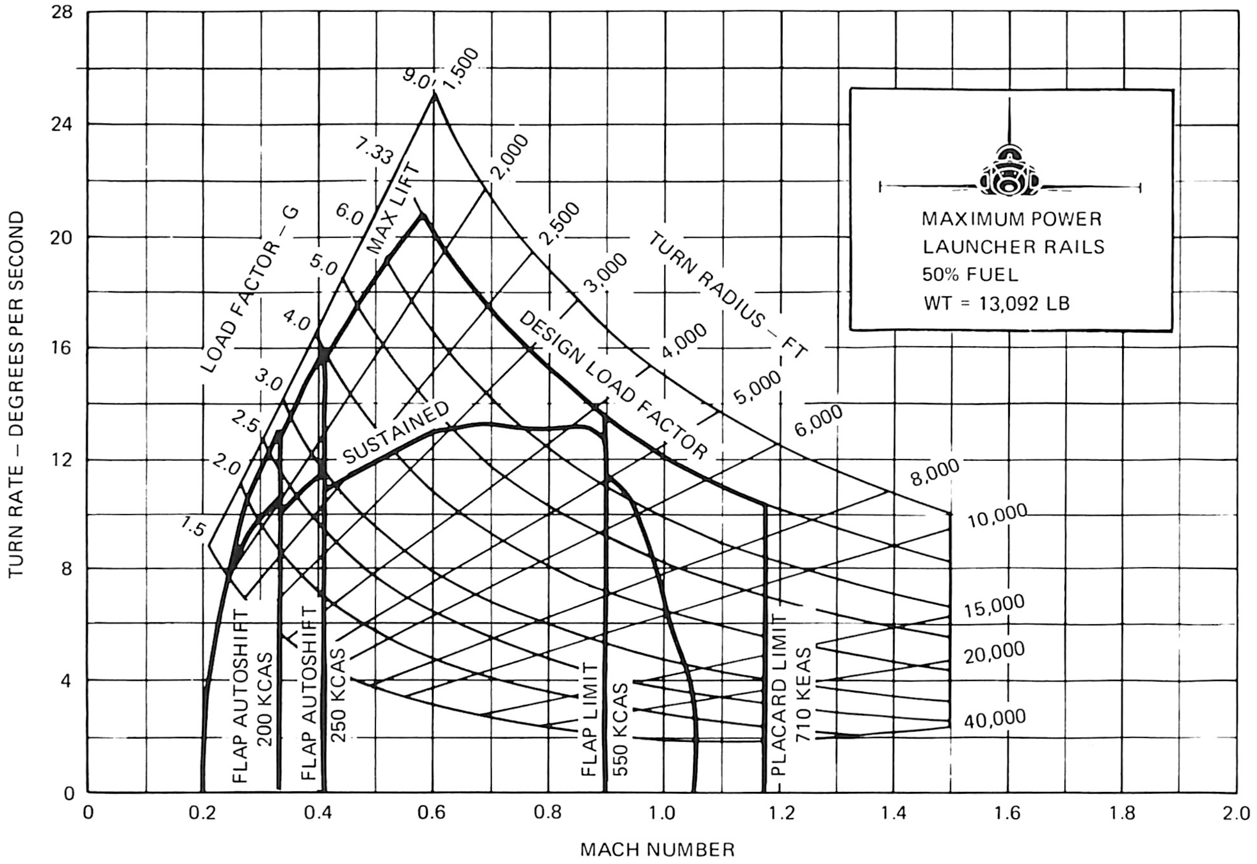


FIGURE 2-47. F-5E TURN PERFORMANCE – 5,000 FT

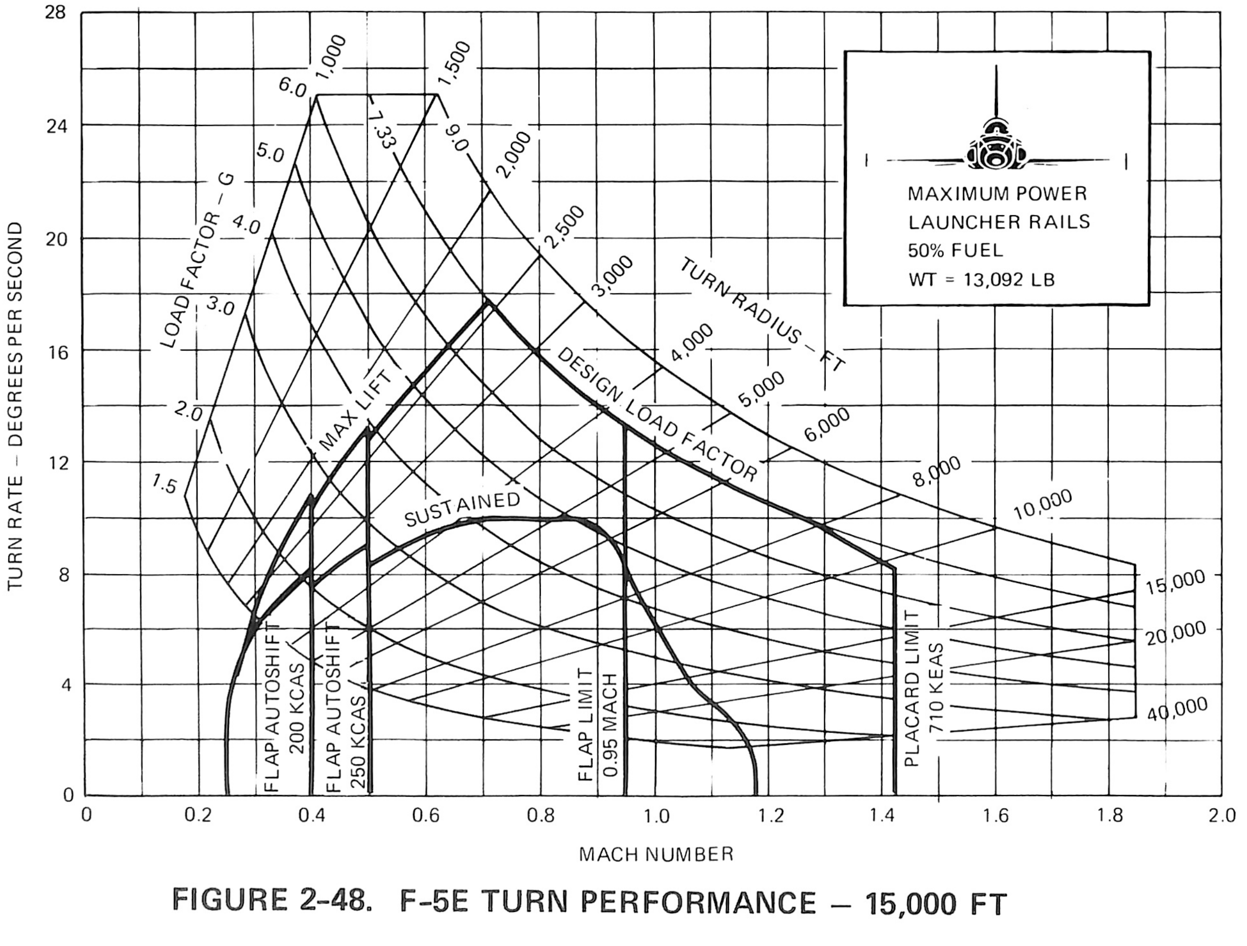


FIGURE 2-48. F-5E TURN PERFORMANCE – 15,000 FT

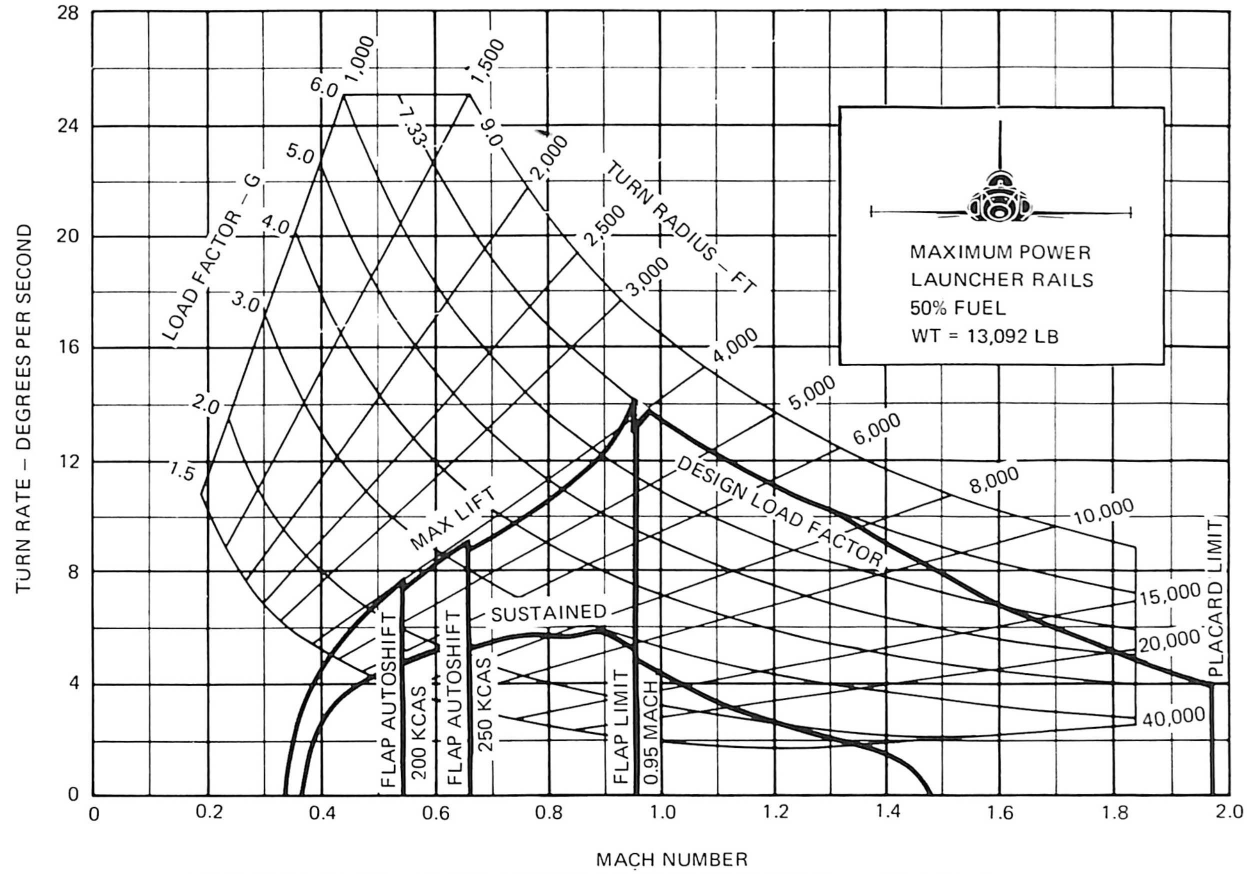


FIGURE 2-49. F-5E TURN PERFORMANCE – 30,000 FEET

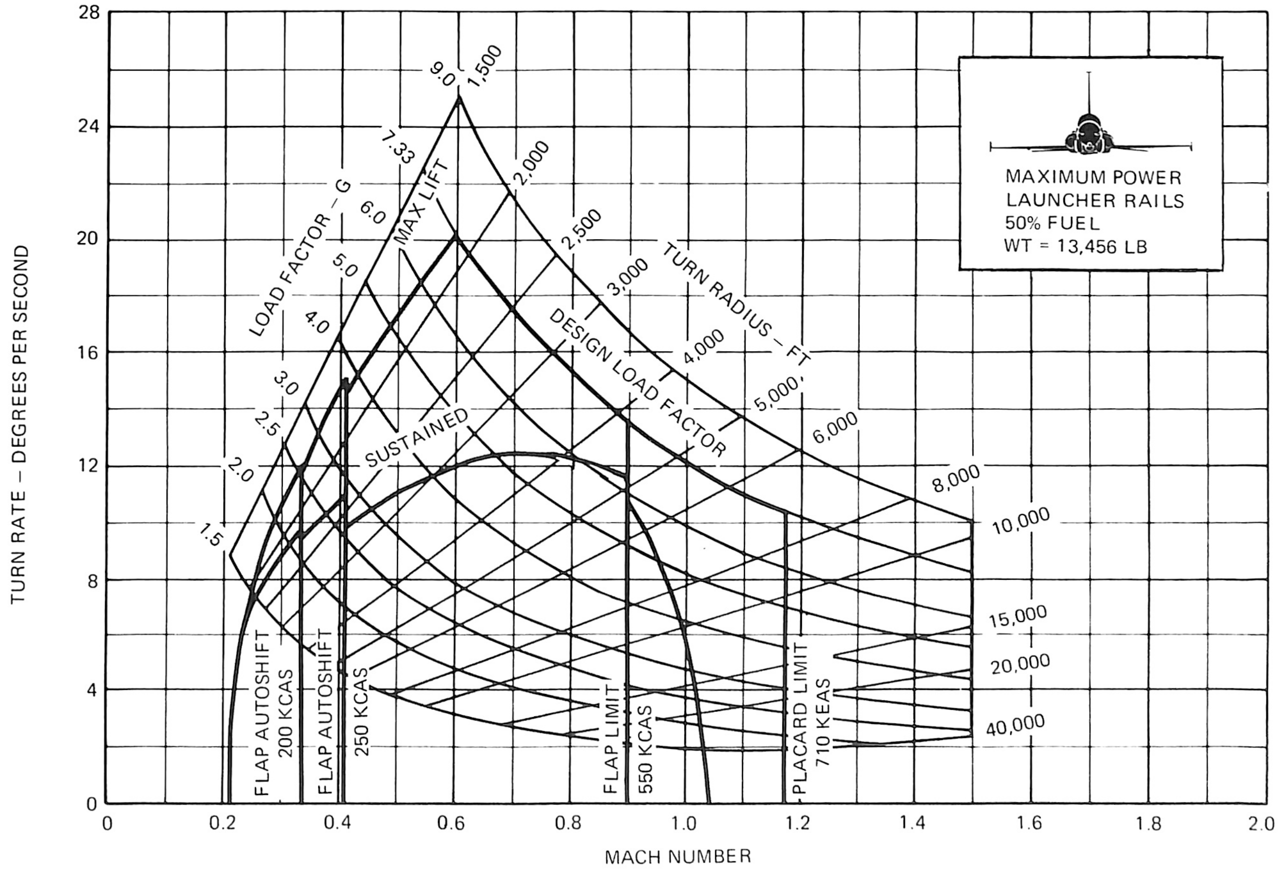


FIGURE 2-50. F-5F TURN PERFORMANCE – 5,000 FEET

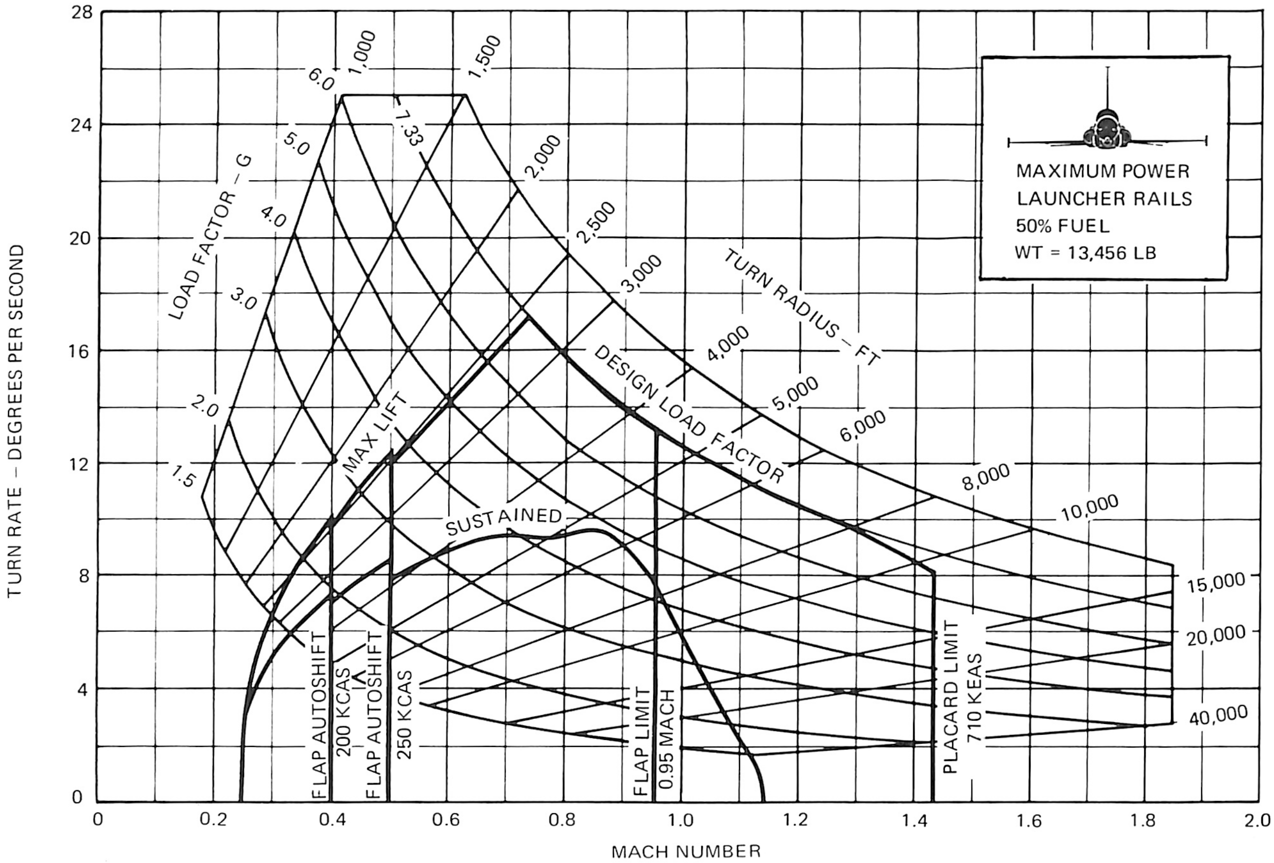


FIGURE 2-51. F-5F TURN PERFORMANCE – 15,000 FEET

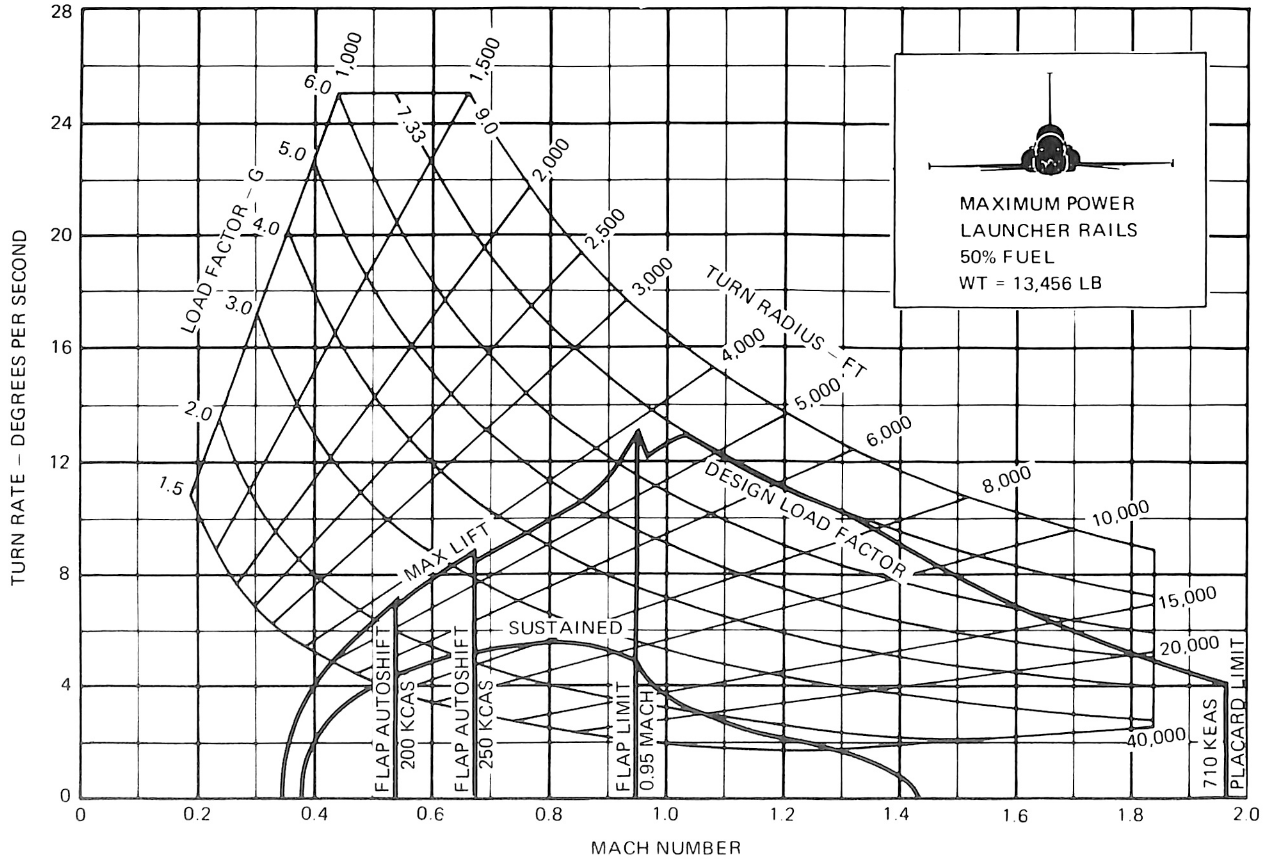


FIGURE 2-52. F-5F TURN PERFORMANCE – 30,000 FEET

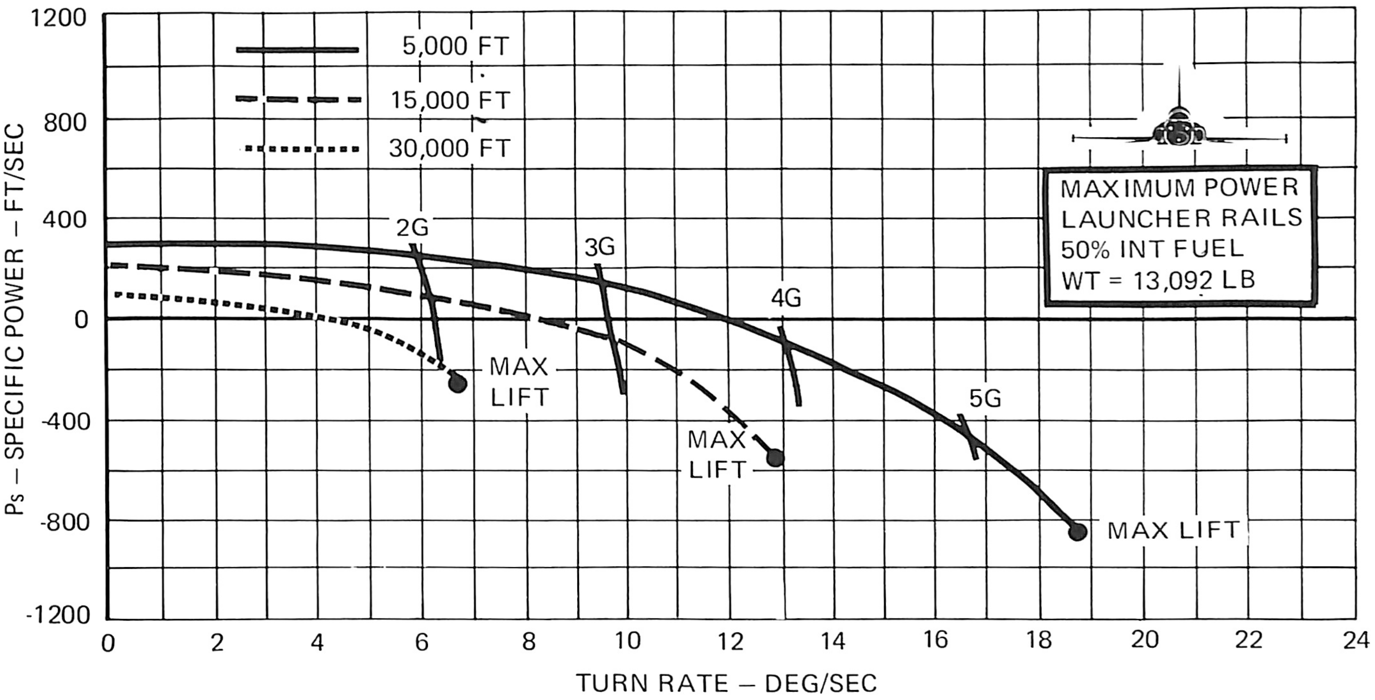


FIGURE 2-53. F-5E SPECIFIC POWER VS TURN RATE – MACH 0.5

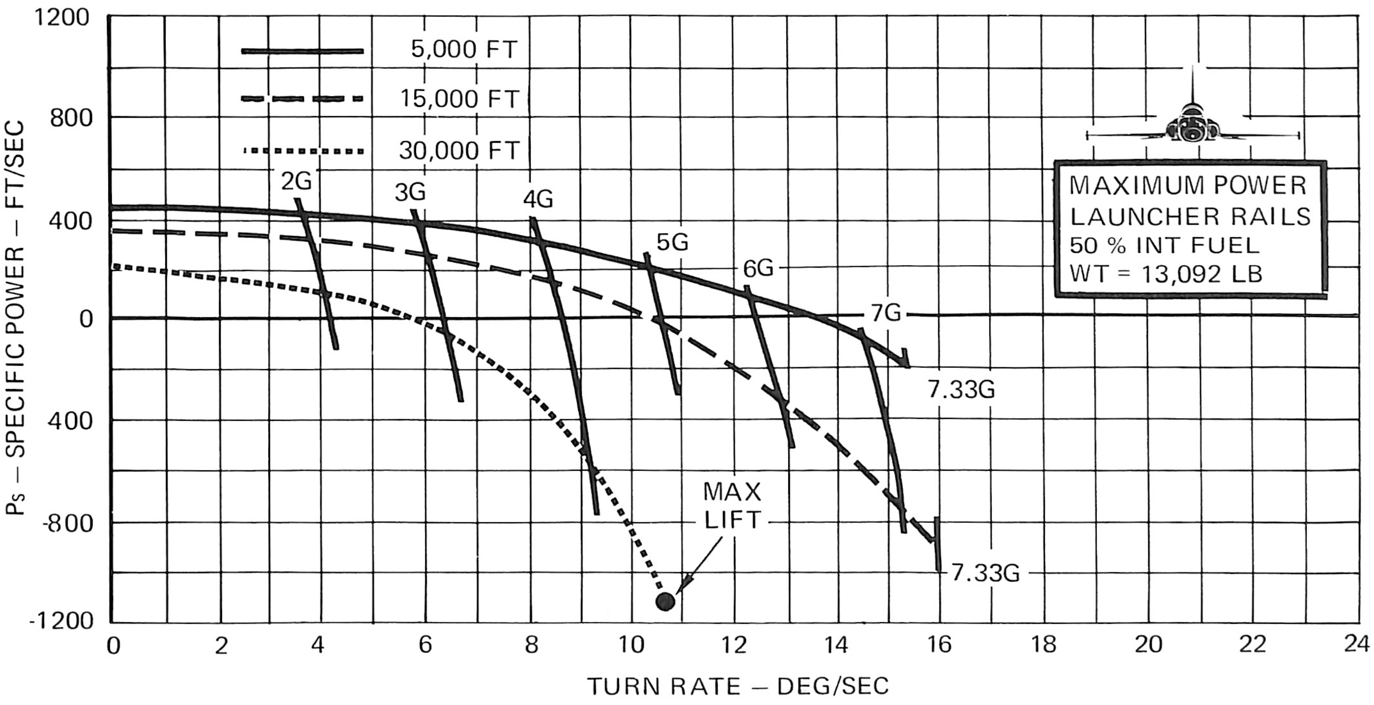


FIGURE 2-54. F-5E SPECIFIC POWER VS TURN RATE – MACH 0.8

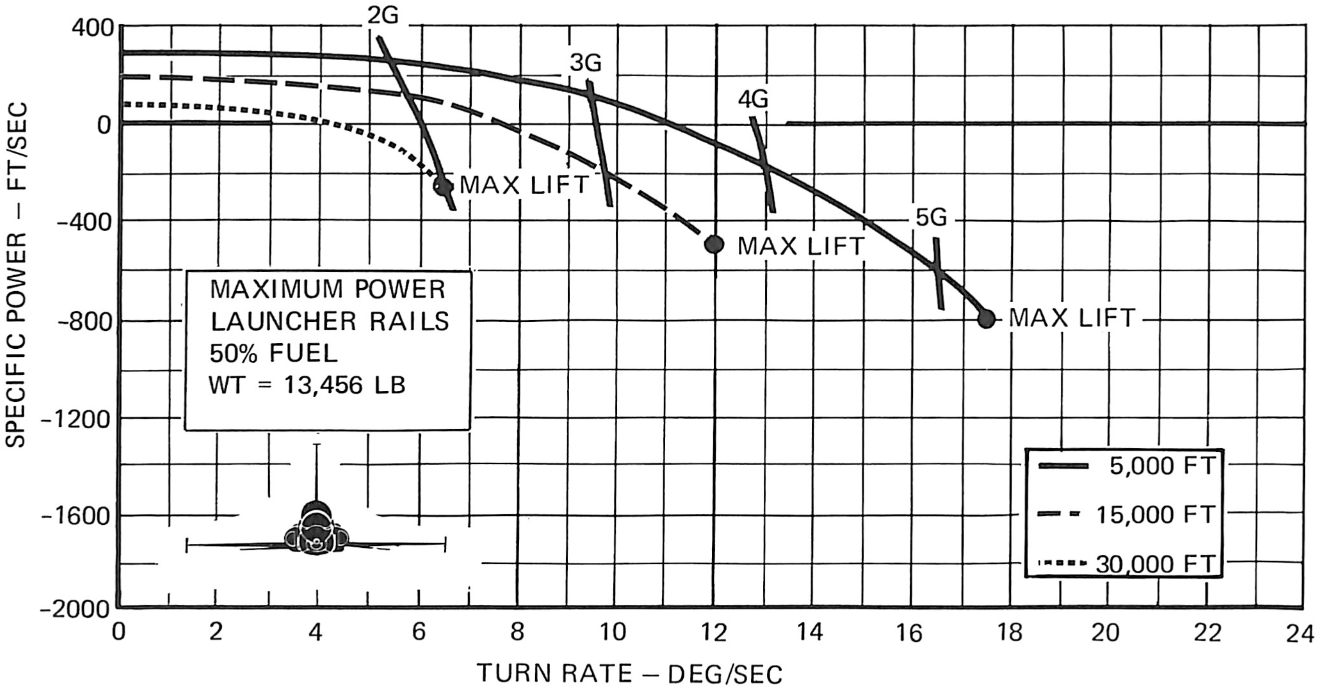


FIGURE 2-55. F-5F SPECIFIC POWER VS TURN RATE – MACH 0.5

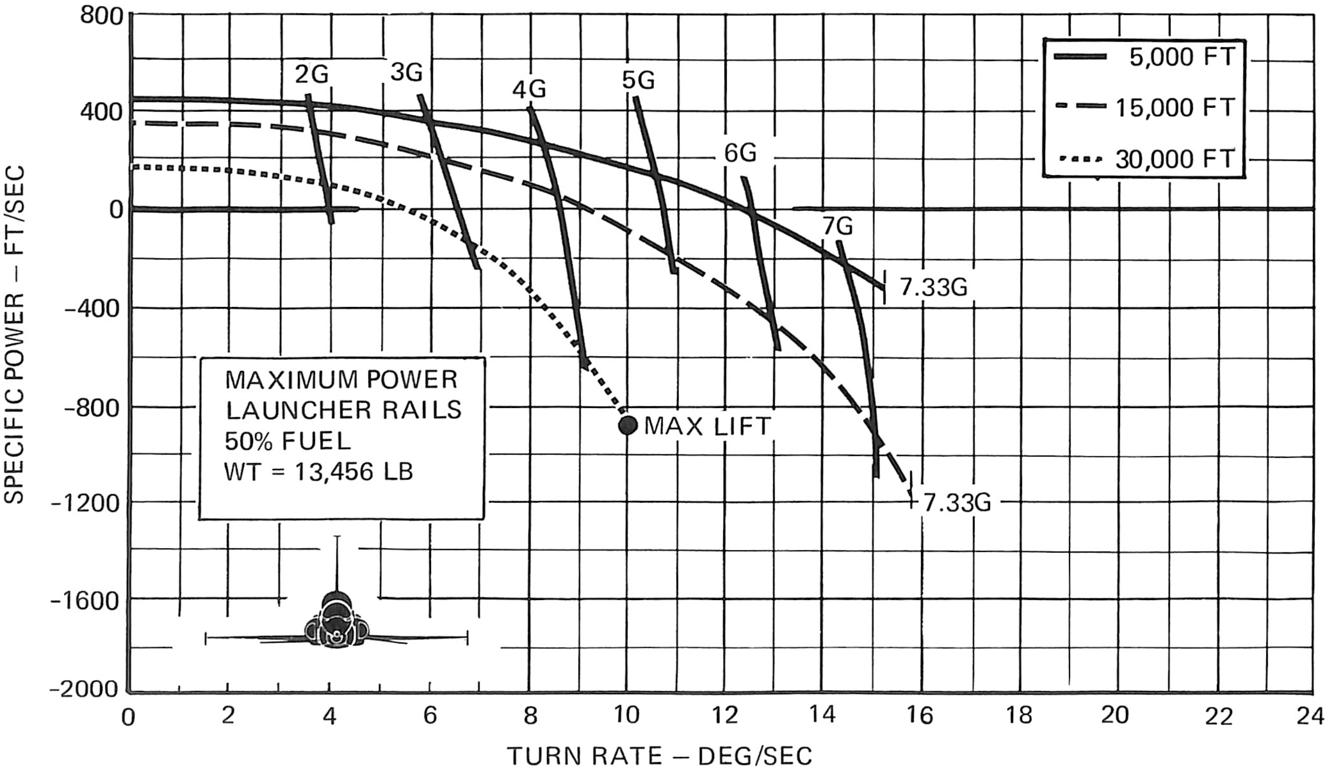


FIGURE 2-56. F-5F SPECIFIC POWER VS TURN RATE – MACH 0.8

Combat Time. The increased internal and external fuel capacity of the F-5E/F provides additional combat time, as shown in Figure 2-57. Combat time is presented at various radii on a typical combat air patrol mission. Three 275-gallon external tanks and jettisonable pylons allow the F-5E/F to patrol long distances, to loiter for extended periods and then to clean up rapidly for air-to-air combat in the presence of enemy fighters.

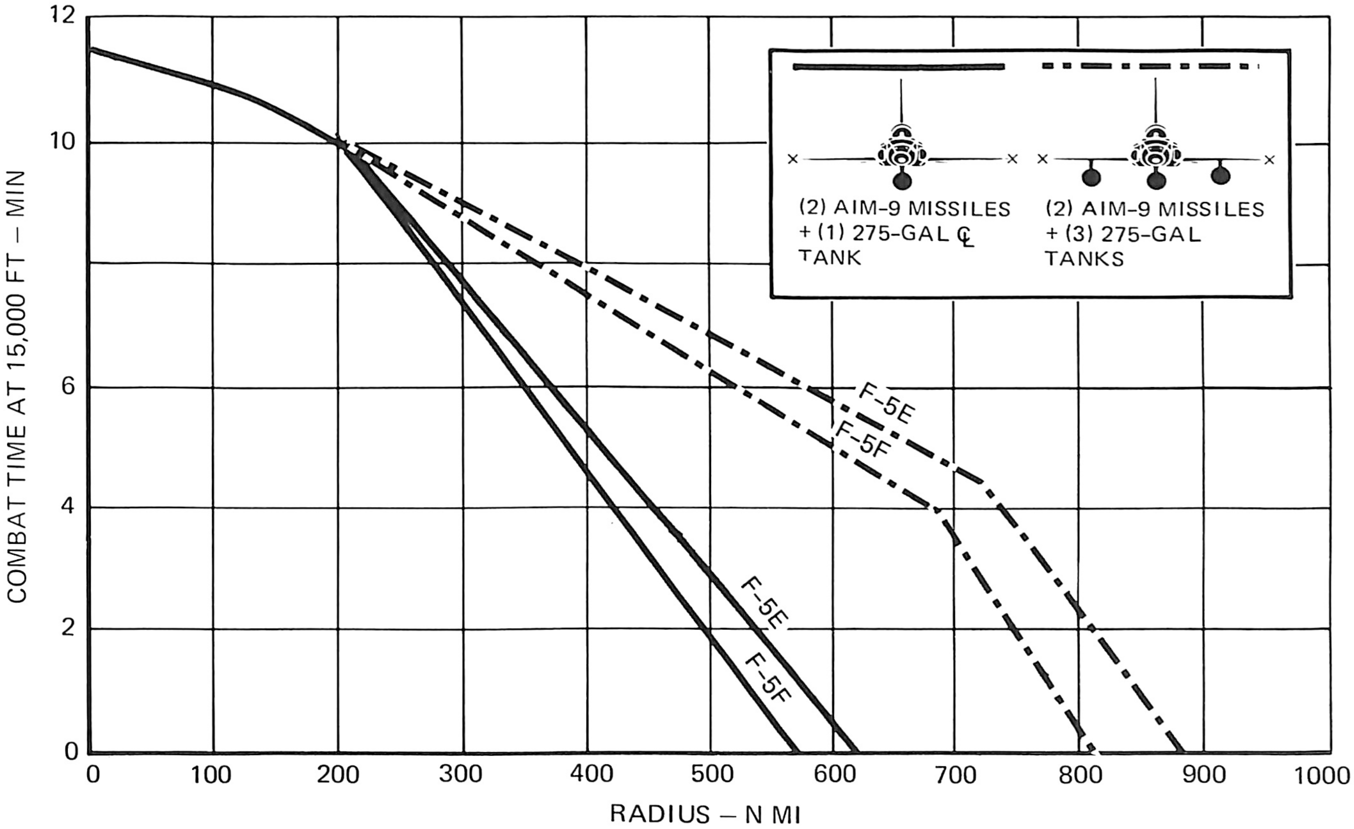


**FIGURE 2-57. F-5E/F COMBAT AIR PATROL COMBAT TIME VS RADIUS**

Detectability and Visibility. Outstanding F-5A/B characteristics which are retained in the F-5E/F are its small physical size, its lack of telltale smoke trail, and its small radar reflectivity characteristics which make it a difficult target to acquire and track. The small size and clean burning engines also make it extremely difficult for opposing pilots to sight the F-5 and to judge range and rate of closure. The F-5E/F provides excellent cockpit visibility and its flying qualities and control characteristics permit the pilot to fly combat missions with minimal references to cockpit instruments. Therefore, the pilot can maintain visual alertness which gives him a considerable advantage over an opponent who has to continuously monitor angle of attack, Mach number and engine instruments in the cockpit.

## SINGLE-ENGINE PERFORMANCE

The F-5E/F aircraft has significant single-engine capability in all flight regimes. The F-5E critical field length required to allow safe operation of the aircraft in the event of an engine failure during the takeoff run is shown in Table 2-5 for various gross weights. Critical-field length and critical-engine-failure speed are defined in Figure 2-58. All of the single-engine takeoff and critical field length performance is based on

TABLE 2-5. F-5E CRITICAL FIELD LENGTH SUMMARY

| GROSS WEIGHT – LB | CRITICAL FIELD LENGTH – FEET | |
|---|---|---|
| | WITH DRAG CHUTE | NO CHUTE |
| 16,000 | 3700 | 3910 |
| 17,000 | 4270 | 4540 |
| 18,000 | 4920 | 5270 |
| 19,000 | 5800 | 6290 |
| 20,000 | 7080 | 7800 |

CG = 12% MAC; SEA LEVEL

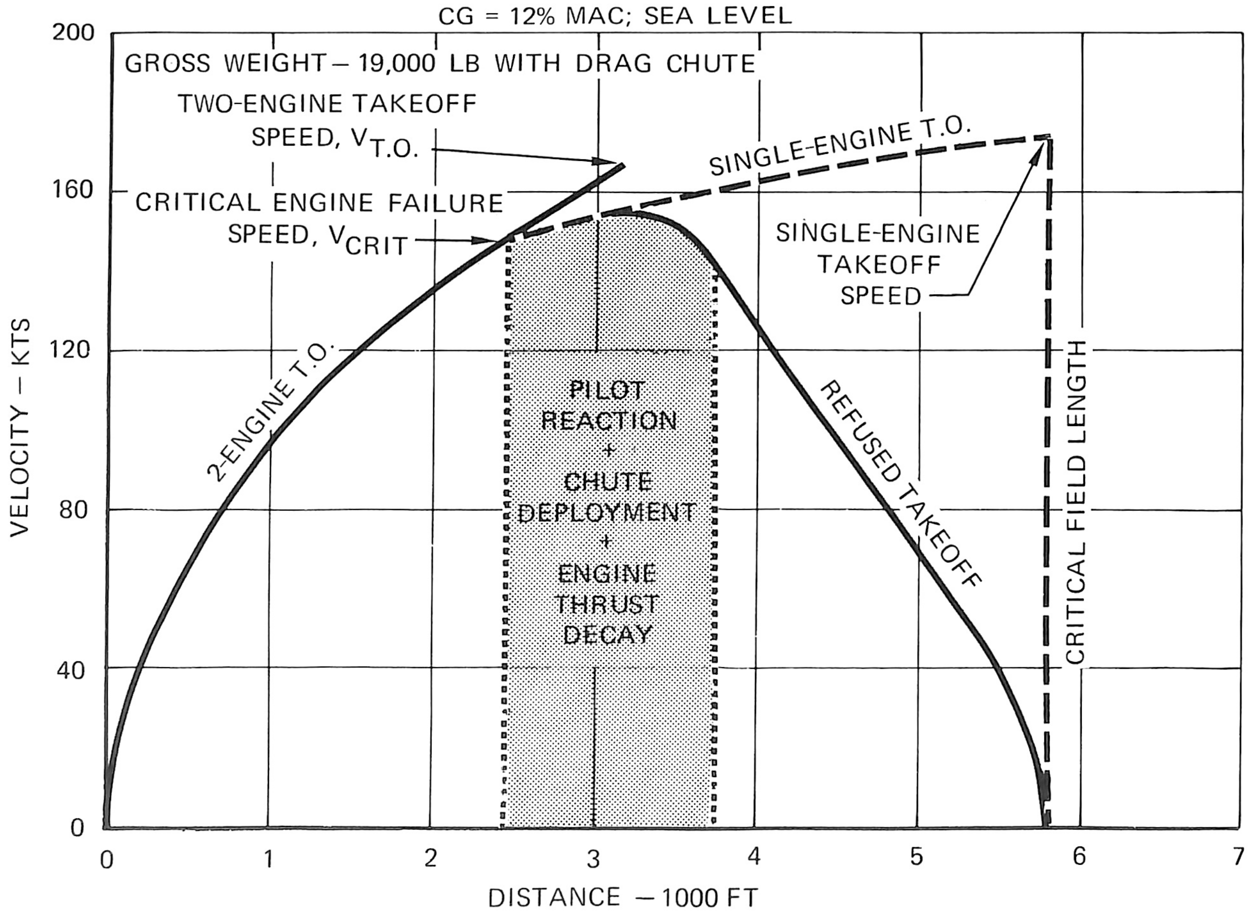


FIGURE 2-58. F-5E CRITICAL FIELD LENGTH DETERMINATION

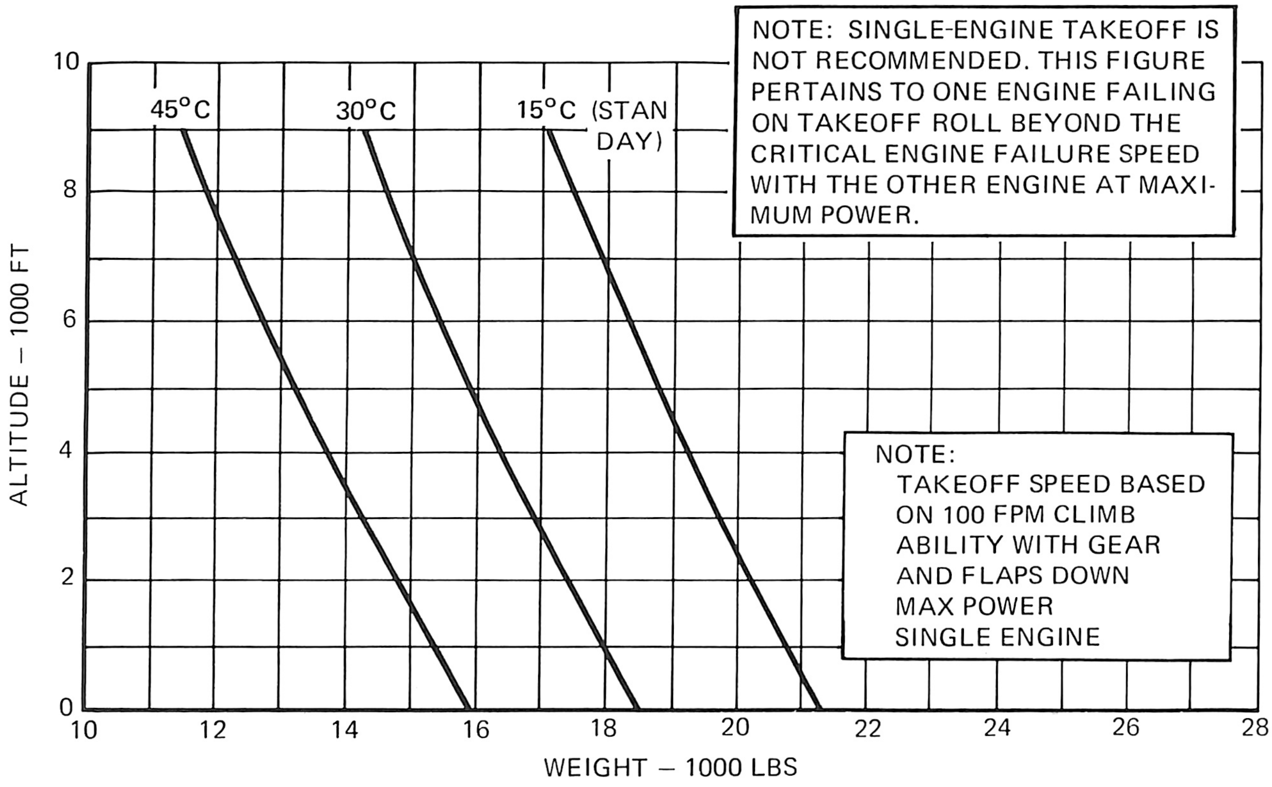
heavy braking and minimum single-engine thrust data and is therefore conservative for airplanes with average engines and experienced pilots. Heavy braking assumes a friction coefficient 8 percent below the maximum braking value (0.275 compared to 0.300 for maximum braking). F-5F single-engine performance closely approximates the F-5E performance shown although the takeoff distances are slightly greater due to the more forward cg location.

At "critical-engine-failure" speed, ($V_{crit}$), the pilot has the choice of continuing the takeoff or stopping on the remaining runway and the total distance is the critical field length. At this speed or above, a successful single-engine takeoff can be made. The critical field length determination in Figure 2-58 allows for realistic pilot reaction time, drag chute deployment time, and engine thrust reduction time.

Maximum single-engine takeoff weight is presented in Figure 2-59. On a 15°C standard day at 1000 feet altitude, the F-5E has a maximum single-engine takeoff weight of 20,751 pounds. A typical heavy-weight example (from Table 2-5 and Figure 2-58) shows that an F-5E at 19,000 pounds can utilize a runway of 5800 feet. If an engine failure occurs before attaining the critical engine failure speed ($V_{crit}$) of 147 KTAS, braking and chute deployment will safely stop the aircraft on the remaining runway. Note that single-engine takeoff is not recommended starting from brake release. Figure 2-59 refers to takeoff capability when engine failure occurs during the takeoff ground roll at or beyond the critical engine failure speed.

Figure 2-60 illustrates the maximum-thrust single-engine performance capability of the aircraft without external stores. The F-5E single-engine climb capability with external stores, including both cleared and growth configurations, is shown in Figure 2-61. The rates of climb shown assume that flap and landing gear have been retracted and that the aircraft is at its best single-engine climb speed.

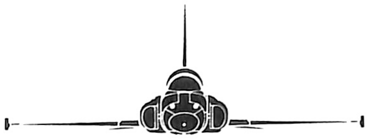
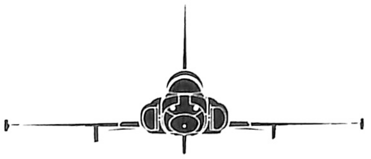
Figure 2-62 shows that single-engine cruise can be maintained with only a 10 percent decrease in nautical miles per pound of fuel (from the two-engine case) at low altitudes, and an approximate 20 percent reduction in miles per pound from dual-engine operation at the single-engine military power service ceiling. Single-engine partial-afterburner cruise can be maintained at altitudes to 36,000 feet. F-5F single-engine performance is comparable to the F-5E values shown, except that the F-5F values will be slightly less due to the 364-lb gross weight difference.



NOTE: SINGLE-ENGINE TAKEOFF IS NOT RECOMMENDED. THIS FIGURE PERTAINS TO ONE ENGINE FAILING ON TAKEOFF ROLL BEYOND THE CRITICAL ENGINE FAILURE SPEED WITH THE OTHER ENGINE AT MAXIMUM POWER.

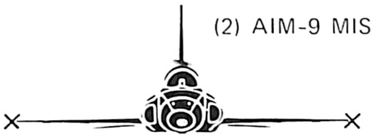
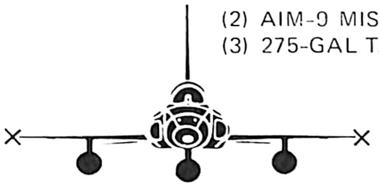
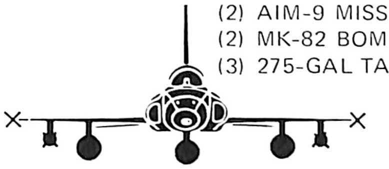
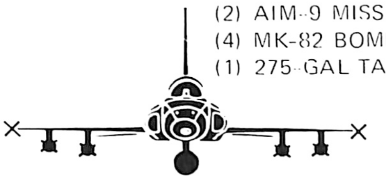
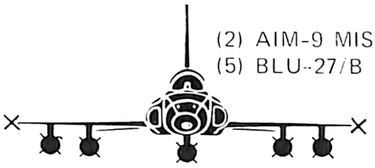
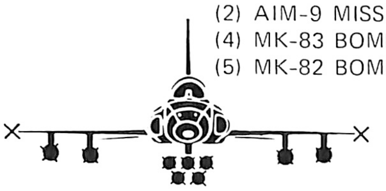
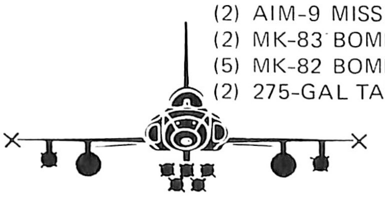
NOTE:
TAKEOFF SPEED BASED ON 100 FPM CLIMB ABILITY WITH GEAR AND FLAPS DOWN
MAX POWER
SINGLE ENGINE

FIGURE 2-59. F-5E MAXIMUM SINGLE-ENGINE TAKEOFF WEIGHT

| CONFIGURATION | WEIGHT (50% FUEL) (LB) | SEA LEVEL RATE OF CLIMB (FPM) * | CRUISE CEILING (FT) ⊛ | COMBAT CEILING (FT) * |
|---|---|---|---|---|
| RAILS  | 13,092 | 6,900 | 20,800 | 41,000 |
| RAILS + (3) PYLONS  | 13,506 | 5,960 | 17,430 | 38,900 |

* MAXIMUM POWER, BEST CLIMB SPEED ⊛ NORMAL POWER, SINGLE ENGINE

FIGURE 2-60. F-5E SINGLE-ENGINE CLIMB AND CEILING CAPABILITY WITHOUT EXTERNAL STORES

| CONFIGURATION | LOADING | WEIGHT (90% FUEL) (LB) | RATE OF* CLIMB (FPM) |
|---|---|---|---|
| INTERCEPT (INTERNAL FUEL) |  (2) AIM-9 MISSILES | 15,192 | 5,570 |
| INTERCEPT OR COMBAT AIR PATROL (MAXIMUM FUEL) |  (2) AIM-9 MISSILES<br>(3) 275-GAL TANKS | 21,078 | 2,610 |
| INTERDICTION OR CLOSE AIR SUPPORT (MAXIMUM FUEL) (MK-82 BOMBS) |  (2) AIM-9 MISSILES<br>(2) MK-82 BOMBS<br>(3) 275-GAL TANKS | 22,396 | 1,890 |
| INTERDICTION OR CLOSE AIR SUPPORT (MAXIMUM FUEL) (MK-82 BOMBS) |  (2) AIM-9 MISSILES<br>(4) MK-82 BOMBS<br>(1) 275-GAL TANK | 19,808 | 2,940 |
| INTERDICTION OR CLOSE AIR SUPPORT (INTERNAL FUEL) |  (2) AIM-9 MISSILES<br>(5) BLU-27/B | 20,112 | 2,590 |
| CLOSE AIR SUPPORT (INTERNAL FUEL) (GROWTH) |  (2) AIM-9 MISSILES<br>(4) MK-83 BOMBS<br>(5) MK-82 BOMBS | 22,657 ⊛ | 1,350 |
| CLOSE AIR SUPPORT MAXIMUM WEIGHT (GROWTH) |  (2) AIM-9 MISSILES<br>(2) MK-83 BOMBS<br>(5) MK-82 BOMBS<br>(2) 275-GAL TANKS | 24,436 ⊛ | 740 |

*MAXIMUM POWER AT BEST CLIMB SPEED.
SEA LEVEL GEAR UP.

⊛ GROWTH LOADINGS

FIGURE 2-61. F-5E SINGLE-ENGINE CLIMB CAPABILITY WITH EXTERNAL STORES

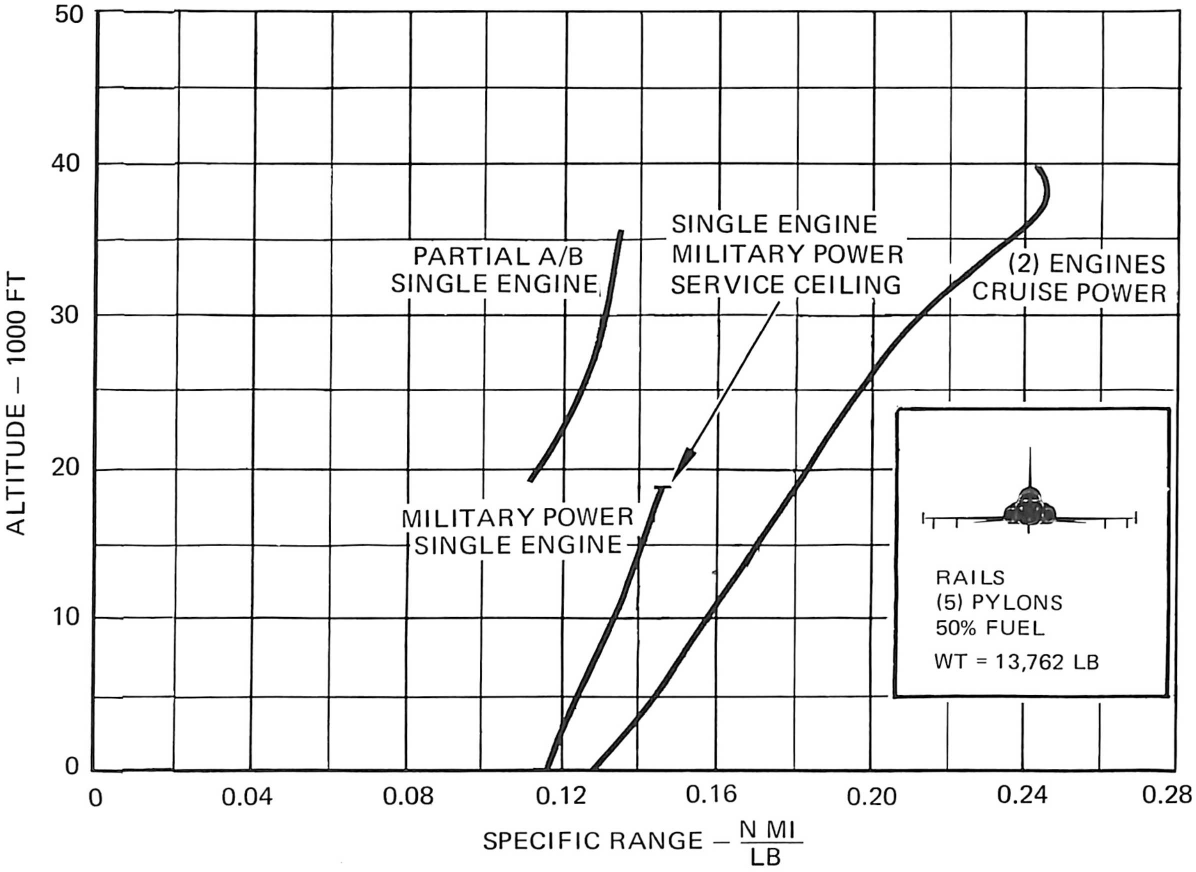


FIGURE 2-62. EFFECT OF SINGLE ENGINE ON F-5E CRUISE PERFORMANCE

## WEIGHTS

A weight summary for the F-5E/F aircraft with JP-4 fuel is presented in Table 2-6. The weights in this table have been used in calculating performance figures. Weights are also shown for various training and operational stores, both cleared and growth loadings. Configuration takeoff weights with JP-4 fuel together with fuel and ordnance loads are shown for the F-5E in Table 2-7 and the F-5F in Table 2-8.

A weight summary for the F-5E/F aircraft with Jet A-1 fuel is presented in Table 2-9.

## TABLE 2-6. F-5E/F WEIGHT SUMMARY – JP-4 FUEL

| AN-9103D GROUP | WEIGHT – LB | |
|---|---|---|
| | F-5E | F-5F |
| WING | 1,315 | 1,327 |
| TAIL | 306 | 306 |
| BODY | 2,648 | 2,863 |
| ALIGHTING GEAR | 765 | 783 |
| SURFACE CONTROLS | 427 | 478 |
| ENGINE SECTION | 174 | 173 |
| PROPULSION | 2,199 | 2,215 |
| INSTRUMENTS | 155 | 195 |
| HYDRAULICS | 152 | 154 |
| ELECTRICAL | 303 | 339 |
| ELECTRONICS | 172 | 178 |
| ARMAMENT | 333 | 300 |
| FURNISHINGS | 243 | 502 |
| AIR CONDITIONING AND ANTI-ICING | 148 | 155 |
| AUXILIARY GEAR | 85 | 92 |
| CONTINGENCY* | 0 | 40 |
| WEIGHT EMPTY | 9,425 | 10,100 |
| PILOT AND EQUIPMENT | 240 | 480 |
| INTERNAL FUEL – USABLE | 4,400 | 4,400 |
| INTERNAL FUEL – UNUSABLE | 140 | 140 |
| ENGINE OIL AND OXYGEN | 31 | 31 |
| GUN INSTALLATION AND CAMERA | 541 | 261 |
| AMMUNITION AND LINKS | 394 | 100 |
| LAUNCHER RAILS | 98 | 98 |
| SURVIVAL KIT | 23 | 46 |
| TAKEOFF WEIGHT (LAUNCHER RAILS) | 15,292 | 15,656 |

### EXTERNAL TANKS AND FUEL

| | VOLUME, USABLE (U.S. GAL.) | TANKS, EMPTY (WT – LB) | FUEL, USABLE (WT – LB) |
|---|---|---|---|
| ℄ PYLON TANK | 150 | 147 | 975 |
| ℄ PYLON TANK (WRM) | 275 | 213 | 1788 |
| INBD PYLON TANKS (2) | 300 | 306 | 1950 |
| INBD PYLON TANKS (2) | 550 | 432 | 3575 |
| WINGTIP TANKS (2) (GROWTH) | 96 | 243 | 624 |

FUEL WEIGHT COMPUTED AT 6.5 LB/GAL.

EMPTY TANK WEIGHTS INCLUDE RESIDUAL FUEL OF 13.0 LB FOR EACH PYLON TANK AND 6.5 LB FOR EACH TIP TANK.

*CONTINGENCY ALLOWANCE TO ACCOUNT FOR WEIGHT GROWTH VARIATION IN THE MODIFIED AREAS OF THE AIRCRAFT DURING DESIGN DEVELOPMENT

## TABLE 2-6. F-5E/F WEIGHT SUMMARY (Continued)

| MUNITIONS | WT – LB EACH |
|---|---|
| AIM-9B MISSILE | 165 |
| AIM-9E MISSILE | 171 |
| AIM-9J MISSILE | 170 |
| AGM-65 MAVERICK MISSILE | 475 |
| MK-81 LDGP BOMB | 260 |
| MK-81 SNAKEYE BOMB | 300 |
| MK-82 LDGP BOMB | 531 |
| MK-82 SNAKEYE BOMB | 570 |
| MK-82 LG BOMB-HS | 643 |
| MK-83 LDGP BOMB | 985 |
| MK-84 LDGP BOMB | 1970 |
| M117 GP BOMB | 824 |
| ROCKEYE II (MK 20 MOD 2) CLUSTER BOMB | 491 |
| MK-36D DESTRUCTOR | 572 |
| M129E2 LEAFLET BOMB | 203 |
| BLU-1/B (W/O FIN) FIREBOMB | 702 |
| BLU-1/B (W/FIN) FIREBOMB | 717 |
| BLU-1B/B (W/O FIN) FIREBOMB | 702 |
| BLU-1B/B (W/FIN) FIREBOMB | 717 |
| BLU-1C/B (W/O FIN) FIREBOMB | 702 |
| BLU-1C/B (W/FIN) FIREBOMB | 717 |
| BLU-27/B (W/O FIN) FIREBOMB | 839 |
| BLU-27/B (W/FIN) FIREBOMB | 854 |
| BLU-27A/B OR B/B (W/O FIN) | 782 |
| BLU-27A/B OR B/B (W/FIN) | 797 |
| BLU-27B/B (W/O FIN) FIREBOMB | 782 |
| BLU-27B/B (W/FIN) FIREBOMB | 797 |
| BLU-32B/B OR 32A/B (W/O FIN) | 582 |
| BLU-32B/B OR 32A/B (W/FIN) | 597 |
| CBU-2A/A DISPENSER (EMPTY) | 121 |
| CBU-2A/A DISPENSER (LOADED) | 830 |
| CBU-24B/B, -49B/B DISPENSER | 822 |
| CBU-58/B OR -71/B | 818 |
| CBU-52A/B DISPENSER | 785 |
| LAU-3/A, -3A/A, -3B/A, -60/A RKT POD (EMPTY) | 74 |
| LAU-3/A, -3A/A, -3B/A, -60/A RKT POD (LOADED) | |
| W/19, 2.75" FFAR, TYPE MK-1 OR MK-5 WARHEADS | 414 |
| W/19, 2.75" FFAR, M151, M156 OR WDU-4A/A WARHEADS | 469 |
| LAU-10/A ROCKET POD (EMPTY) | 105 |
| LAU-10/A (LOADED) W/4, 5.0" HVAR | 533 |
| LAU-68A/A ROCKET POD (EMPTY) | 71 |
| LAU-68A/A (LOADED) | |
| W/7, 2.75" FFAR, TYPE MK-1 OR MK-5 WARHEADS | 195 |
| W/7, 2.75" FFAR, M151 WARHEADS | 215 |
| SUU-25A/A DISPENSER (EMPTY) | 160 |
| SUU-25A/A (LOADED) | |
| W/MK-24 MOD 1 OR MOD 2 FLARES | 352 |
| W/MK-24 MOD 3 OR MOD 4 FLARES | 376 |
| W/LUU-1/B OR -5/B FLARES | 368 |
| W/LUU-2/B FLARES | 400 |
| SUU-25C/A (EMPTY) | 262 |
| SUU-25C/A (LOADED) | 497 |

| AMMUNITION F-5E | WT – LB |
|---|---|
| 20MM LINKS, RETAINED | 80 |
| 560 ROUNDS 20MM, EXPENDABLE | 314 |
| (1) ROUND 20MM, EXPENDABLE | 0.56 |

| AMMUNITION F-5F | WT – LB |
|---|---|
| 20MM LINKS, RETAINED | 21 |
| 140 ROUNDS 20MM, EXPENDABLE | 79 |
| (1) ROUND 20MM, EXPENDABLE | 0.56 |

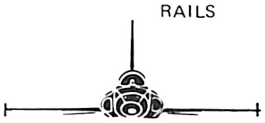
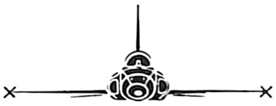
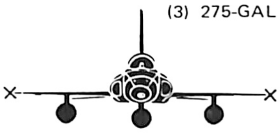
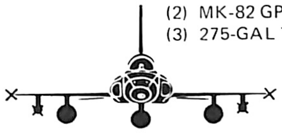
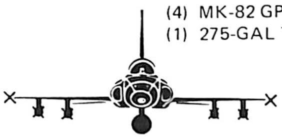
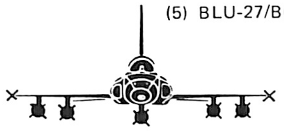
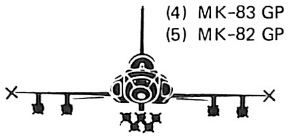
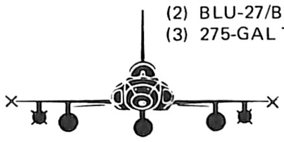
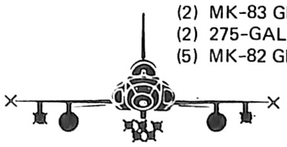
| ACCESSORIES | WT – LB EACH |
|---|---|
| WINGTIP MISSILE LAUNCHER | 49 |
| AGM-65 LAUNCHER | 125 |
| ℄ PYLON | 170 |
| INBOARD PYLON | 122 |
| OUTBOARD PYLON | 128 |
| ℄ MER | 190 |
| TER | 97 |
| PYLON JETTISON KIT (ALL 5 PYLONS) | 24 |

| TRAINING EQUIPMENT | WT – LB EACH |
|---|---|
| CBU-9/A DISPENSER (EMPTY) | 121 |
| CBU-9/A DISPENSER (LOADED) | 830 |
| TDU-11/B TARGET ROCKET | 215 |
| SUU-20/A(M), DISPENSER (EMPTY) | 320* |
| SUU-20/A(M), DISPENSER (LOADED) | |
| W/4, 2.75" FFAR AND 6, BDU-33 SERIES BOMBS | 535* |
| W/4, 2.75" FFAR AND 6, MK-106 PRACTICE BOMBS | 425* |
| DART TOW TARGET SYSTEM | |
| BOOM ADAPTER | 98 |
| TARGET BOOM | 172 |
| TDU-10/B DART TOW TARGET | 197 |
| RMU-10A TOW REEL POD (W/O CABLE) | 302 |
| CABLE (RMU-10A POD) | 173 |

TABLE INCLUDES GROWTH ITEMS.

*5 LB HEAVIER WITH SUU-20A/A

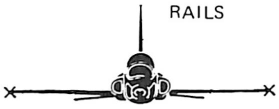
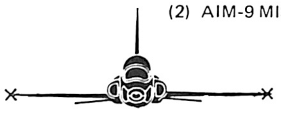
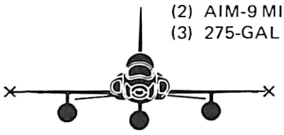
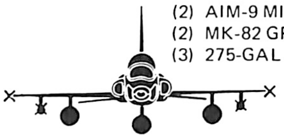
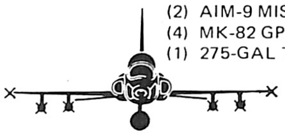
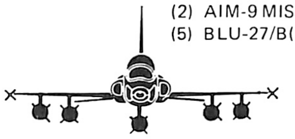
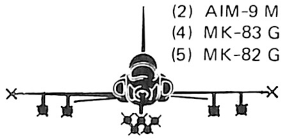
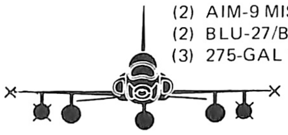
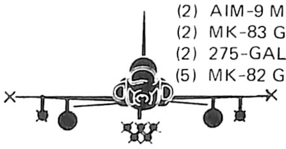
## TABLE 2-7. F-5E CONFIGURATION TAKEOFF WEIGHTS WITH JP-4 FUEL

| CONFIGURATION | LOADING | T.O. GROSS (LB) | TOTAL USABLE FUEL LOAD (LB) | TOTAL ORDNANCE LOAD ** (LB) |
|---|---|---|---|---|
| LAUNCHER RAILS ONLY | RAILS  | 15,292 | 4,400 | 394 |
| INTERCEPT (INTERNAL FUEL) | (2) AIM-9 MISSILES  | 15,632 | 4,400 | 734 |
| INTERCEPT OR COMBAT AIR PATROL (MAXIMUM FUEL) | (2) AIM-9 MISSILES<br>(3) 275-GAL TANKS  | 22,054 | 9,763 | 734 |
| INTERDICTION OR CLOSE AIR SUPPORT (MAXIMUM FUEL) | (2) AIM-9 MISSILES<br>(2) MK-82 GP BOMBS<br>(3) 275-GAL TANKS  | 23,372 | 9,763 | 1,796 |
| INTERDICTION OR CLOSE AIR SUPPORT | (2) AIM-9 MISSILES<br>(4) MK-82 GP BOMBS<br>(1) 275-GAL TANK  | 20,427 | 6,188 | 2,858 |
| INTERDICTION OR CLOSE AIR SUPPORT (INTERNAL FUEL) | (2) AIM-9 MISSILES<br>(5) BLU-27/B(F)  | 20,572 | 4,400 | 5,004 |
| CLOSE AIR SUPPORT (INTERNAL FUEL) (GROWTH) | (2) AIM-9 MISSILES<br>(4) MK-83 GP BOMBS<br>(5) MK-82 GP BOMBS  | 23,087 | 4,400 | 7,329 |
| MAX GROSS WT | (2) AIM-9 MISSILES<br>(2) BLU-27/B(F)<br>(3) 275-GAL TANKS  | 24,018 | 9,763 | 2,464 |
| MAX GROSS WT (GROWTH) | (2) AIM-9 MISSILES<br>(2) MK-83 GP BOMBS<br>(2) 275-GAL TANKS<br>(5) MK-82 GP BOMBS  | 25,124* | 7,975 | 5,359 |

* 24,280 LB WITH SINGLE BOMBS

** INCLUDES FULL AMMO AND MISSILES IF CARRIED

## TABLE 2-8. F-5F CONFIGURATION TAKEOFF WEIGHTS WITH JP-4 FUEL

| CONFIGURATION | LOADING | *** T.O. GROSS (LB) | TOTAL USABLE FUEL LOAD (LB) | TOTAL ORDNANCE LOAD ** (LB) |
|---|---|---|---|---|
| LAUNCHER RAILS ONLY | <br>RAILS | 15,656 | 4,400 | 100 |
| INTERCEPT (INTERNAL FUEL) | <br>(2) AIM-9 MISSILES | 15,996 | 4,400 | 440 |
| INTERCEPT OR COMBAT AIR PATROL (MAXIMUM FUEL) | <br>(2) AIM-9 MISSILES<br>(3) 275-GAL TANKS | 22,418 | 9,763 | 440 |
| INTERDICTION OR CLOSE AIR SUPPORT (MAXIMUM FUEL) | <br>(2) AIM-9 MISSILES<br>(2) MK-82 GP BOMBS<br>(3) 275-GAL TANKS | 23,736 | 9,763 | 1,502 |
| INTERDICTION OR CLOSE AIR SUPPORT | <br>(2) AIM-9 MISSILES<br>(4) MK-82 GP BOMBS<br>(1) 275-GAL TANK | 20,791 | 6,188 | 2,564 |
| INTERDICTION OR CLOSE AIR SUPPORT (INTERNAL FUEL) | <br>(2) AIM-9 MISSILES<br>(5) BLU-27/B(F) | 20,936 | 4,400 | 4,710 |
| CLOSE AIR SUPPORT (INTERNAL FUEL) (GROWTH) | <br>(2) AIM-9 MISSILES<br>(4) MK-83 GP BOMBS<br>(5) MK-82 GP BOMBS | 23,451 | 4,400 | 7,035 |
| MAX GROSS WT | <br>(2) AIM-9 MISSILES<br>(2) BLU-27/B(F)<br>(3) 275-GAL TANKS | 24,382 | 9,763 | 2,148 |
| MAX GROSS WT (GROWTH) | <br>(2) AIM-9 MISSILES<br>(2) MK-83 GP BOMBS<br>(2) 275-GAL TANKS<br>(5) MK-82 GP BOMBS | 25,488 * | 7,975 | 5,065 |

* 24,644 LB WITH SINGLE BOMBS

** INCLUDES FULL AMMO AND MISSILES IF CARRIED

*** (2) CREW

## TABLE 2-9. F-5E/F WEIGHT SUMMARY WITH JET A-1 FUEL

| AN-9103D GROUP | WEIGHT – LB | |
|---|---|---|
| | F-5E | F-5F |
| WING | 1,315 | 1,327 |
| TAIL | 306 | 306 |
| BODY | 2,648 | 2,863 |
| ALIGHTING GEAR | 765 | 783 |
| SURFACE CONTROLS | 427 | 478 |
| ENGINE SECTION | 174 | 173 |
| PROPULSION | 2,199 | 2,215 |
| INSTRUMENTS | 155 | 195 |
| HYDRAULICS | 152 | 154 |
| ELECTRICAL | 303 | 339 |
| ELECTRONICS | 172 | 178 |
| ARMAMENT | 333 | 300 |
| FURNISHINGS | 243 | 502 |
| AIR CONDITIONING AND ANTI-ICING | 148 | 155 |
| AUXILIARY GEAR | 85 | 92 |
| CONTINGENCY* | 0 | 40 |
| **WEIGHT EMPTY** | 9,425 | 10,100 |
| PILOT AND EQUIPMENT | 240 | 480 |
| INTERNAL FUEL – USABLE (JET A-1) | 4,535 | 4,535 |
| INTERNAL FUEL – UNUSABLE (JET A-1) | 144 | 144 |
| ENGINE OIL AND OXYGEN | 31 | 31 |
| GUN INSTALLATION AND CAMERA | 541 | 261 |
| AMMUNITION AND LINKS | 394 | 100 |
| LAUNCHER RAILS | 98 | 98 |
| SURVIVAL KIT | 23 | 46 |
| **TAKEOFF WEIGHT (LAUNCHER RAILS)** | 15,431 | 15,795 |

EXTERNAL TANKS AND JET A-1 FUEL

| | VOLUME, USABLE (U.S. GAL.) | TANKS, EMPTY (WT – LB) | FUEL, USABLE (WT – LB) |
|---|---|---|---|
| ℄ PYLON TANK | 150 | 147 | 1001 |
| ℄ PYLON TANK | 275 | 214 | 1842 |
| INBD PYLON TANKS (2) | 300 | 307 | 2008 |
| INBD PYLON TANKS (2) | 550 | 433 | 3682 |
| WINGTIP TANKS (2) (GROWTH) | 96 | 243 | 642 |

FUEL WEIGHT COMPUTED AT 6.7 LB/GAL., JET A-1.

EMPTY TANK WEIGHTS INCLUDE RESIDUAL FUEL OF 13.5 LB FOR EACH PYLON TANK AND 6.7 LB FOR EACH TIP TANK.

# SECTION 3

# STABILITY AND CONTROL AND HANDLING QUALITIES

The F-5E/F aircraft retain the same stability and control characteristics and handling qualities that have made the F-5A/B fighters successful in both combat and competitive evaluations. Most of the curves shown in this section are derived from F-5E flight test data. F-5F curves include adjustments for configuration differences between the F-5E and F-5F airplanes, based on F-5F wind tunnel data.

## FLIGHT CHARACTERISTICS – AIM-9 MISSILE CONFIGURATION

### Low Speed Regime

Handling qualities of the AIM-9 missile configuration in the takeoff, operation, and landing modes are excellent. Longitudinal static stability is positive throughout the speed range and with landing flaps and the landing gear down increases at the approach to stall as shown in Figure 3-1. Static longitudinal stability is indicated by the slope of the curves of horizontal tail deflection versus velocity. With trailing edge up

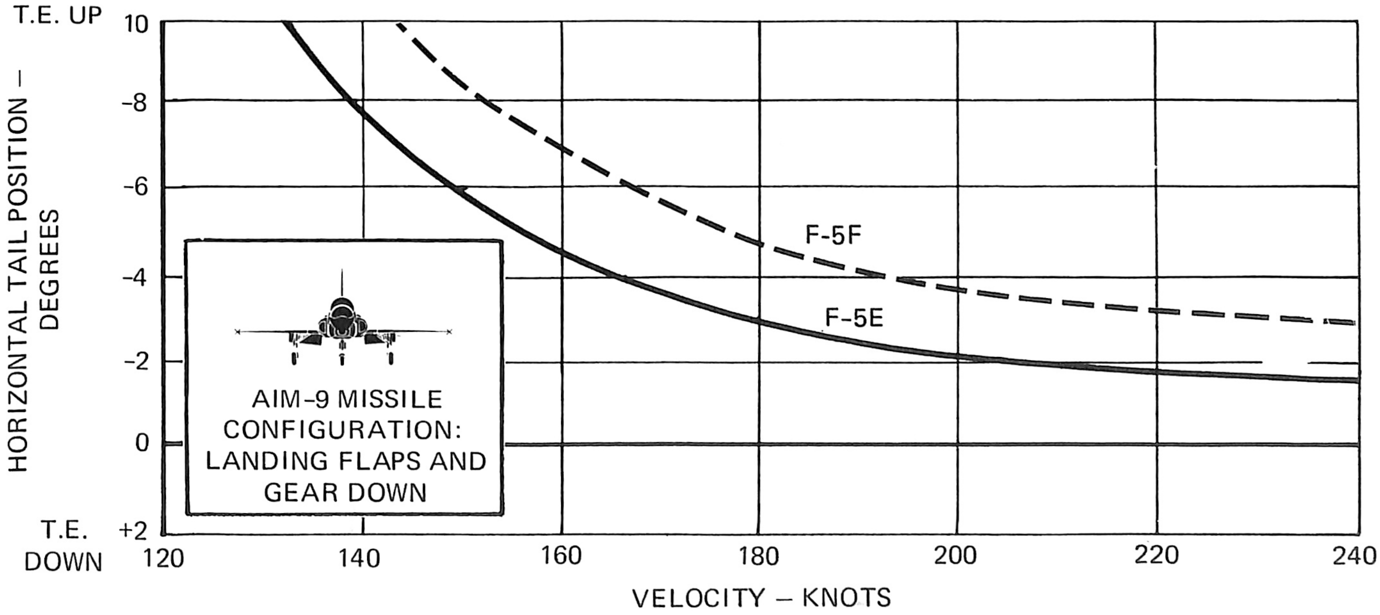


FIGURE 3-1. STATIC LONGITUDINAL STABILITY

considered as negative tail deflection, a positive slope, down and to the right, is stable. The steeper the slope, the greater the stability. Note that the Figure 3-1 curve slopes become steeper, i.e., increasingly positive as velocity decreases. In the pilot's point-of-view, a statically stable airplane is one in which he pulls back on the stick to go slower and pushes forward to go faster. The F-5E/F directional stability is also positive and the rudder provides increasing sideslip angle up to its maximum deflection without reversal of aileron control.

Approach to the stall is characterized by a smooth buffet onset, gradual increase in buffet level, and minor lateral oscillations. Complete control in the full stall condition is maintained with ailerons and rudder. At the stall there is no abrupt pitching of the aircraft, even at high sink rates. The poststall motions are easily controlled and return to level flight is accomplished smoothly. The F-5E/F is completely free of pitch-up tendencies or loss of control over the entire operational load factor range.

Lateral control is adequate throughout the low-speed range, and bank angle corrections can be accomplished with very little stick motion at comfortable stick force levels. Operation of flaps produces only minor trim changes due to the interconnect between the flaps and the horizontal tail. A speedbrake-to-horizontal-tail interconnect also minimizes trim changes when speedbrakes are extended.

Stick forces range from light to moderate for a normal landing approach. Extension or retraction of the landing gear is accomplished with negligible trim change and speedbrakes may be used for approach flightpath control with only a moderate increase in buffet level. Control force harmony for pitch and roll control is maintained from landing-gear-down speed through to touchdown.

### High Speed Regime — Longitudinal Characteristics

Positive static stability prevails for the AIM-9 missile configuration throughout the high-speed region. With the exception of the low supersonic region above 25,000 feet altitude, the slight trim changes that occur with Mach number are always in the direction of positive stability. Above 25,000 feet altitude, the F-5E/F exhibits a characteristic transonic trim change, but the reduction in stability is small, as illustrated in Figure 3-2.

The F-5E/F exhibits satisfactory maneuvering stability characteristics with no tendency to pitchup or to tuck-under in any part of the high-speed flight regime. The variation of stick force gradient (pounds of stick force per g) with changing Mach number is gradual as shown in Figure 3-3.

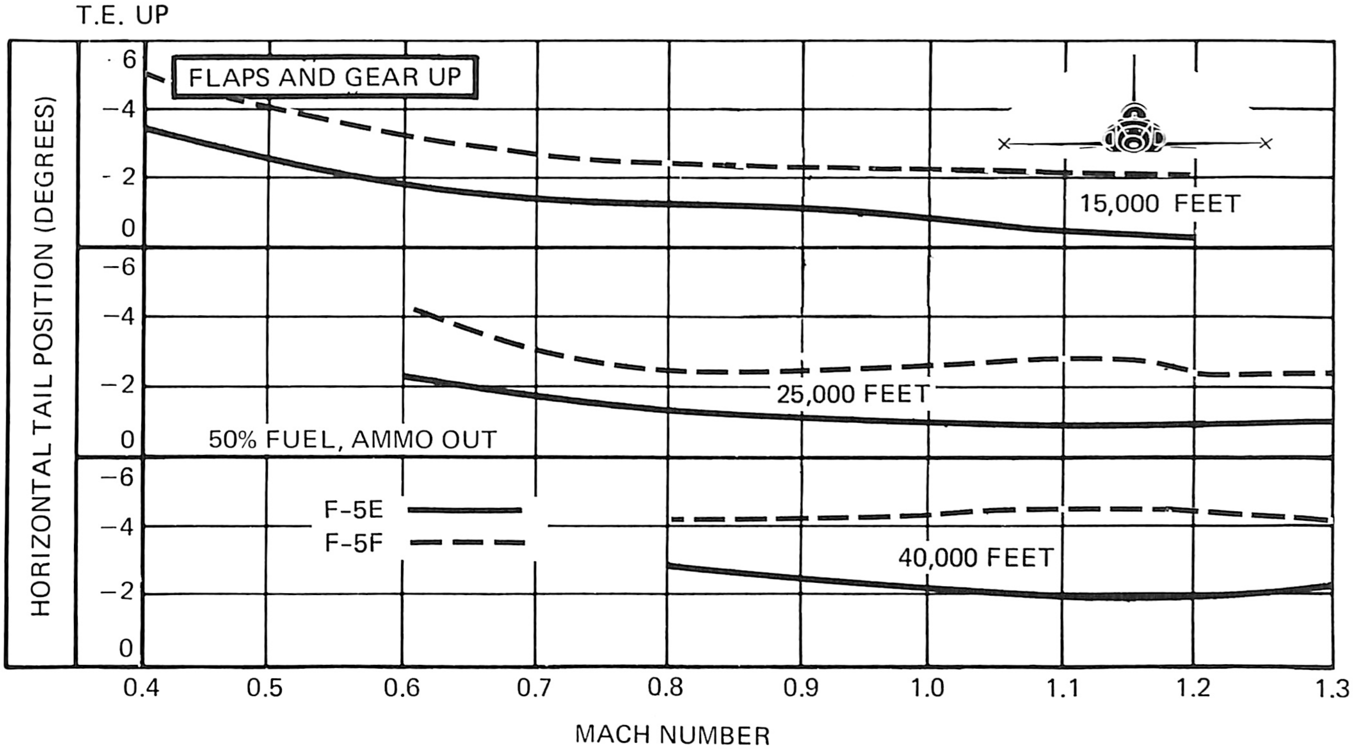


FIGURE 3-2. HIGH-SPEED LONGITUDINAL STATIC STABILITY

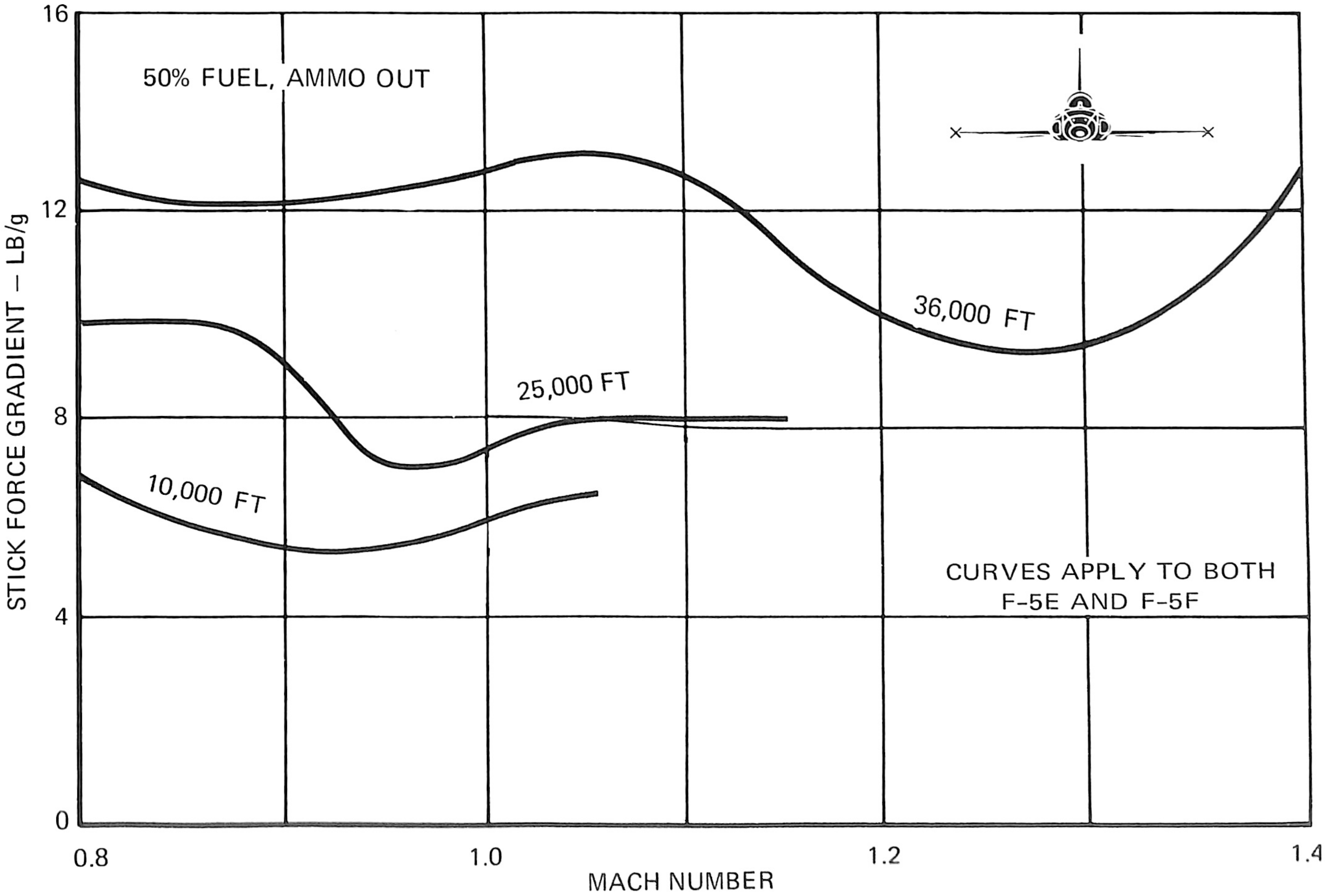


FIGURE 3-3. STICK FORCE GRADIENT VS MACH NUMBER RELATIONSHIP

Figure 3-4 shows that the stick force buildup is approximately linear with load factor except around the trim position. A tri-gradient spring, employed to provide good controllability with small stick deflections, is responsible for the nonlinearity near one g.

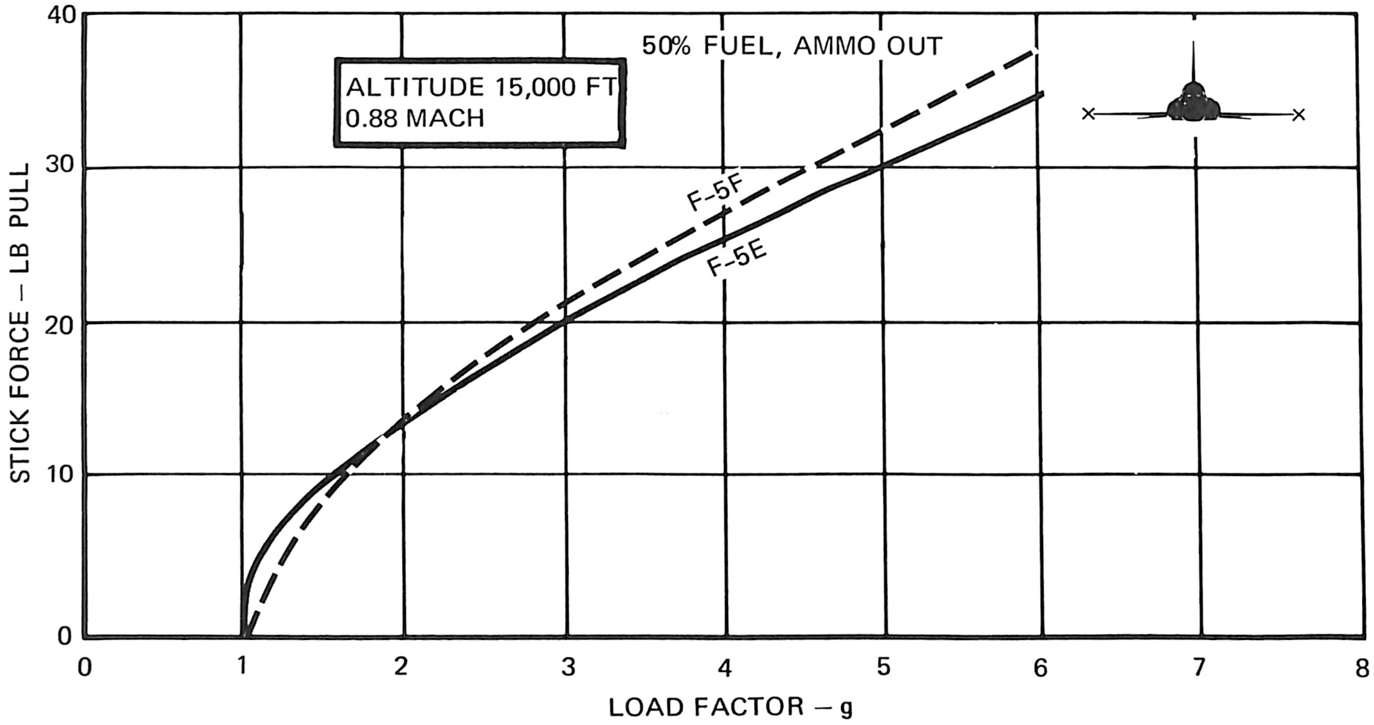


FIGURE 3-4. STICK FORCE VS LOAD FACTOR

The variation of horizontal tail position with load factor is linear as shown by Figure 3-5 which presents typical variations for Mach 0.88 and 15,000 feet altitude. A linear tail deflection versus load factor relationship is highly desirable and indicates complete freedom from any unfavorable flight characteristics.

The unaugmented longitudinal short period damping characteristics shown in Figure 3-6 are good with damping in less than 0.5 cycles throughout the subsonic region and generally less than 1 cycle supersonically at high altitude. Positive dynamic stability allows the aircraft to be flown safely without augmentation. The F-5E/F has stability augmentation in both the pitch and yaw modes. With pitch augmentation engaged, the longitudinal short period damping is further improved.

## Precision Tracking

The ability of the pilot to perform precision tracking was well demonstrated during the course of simulated air combat engagements of the F-5A/B's against other

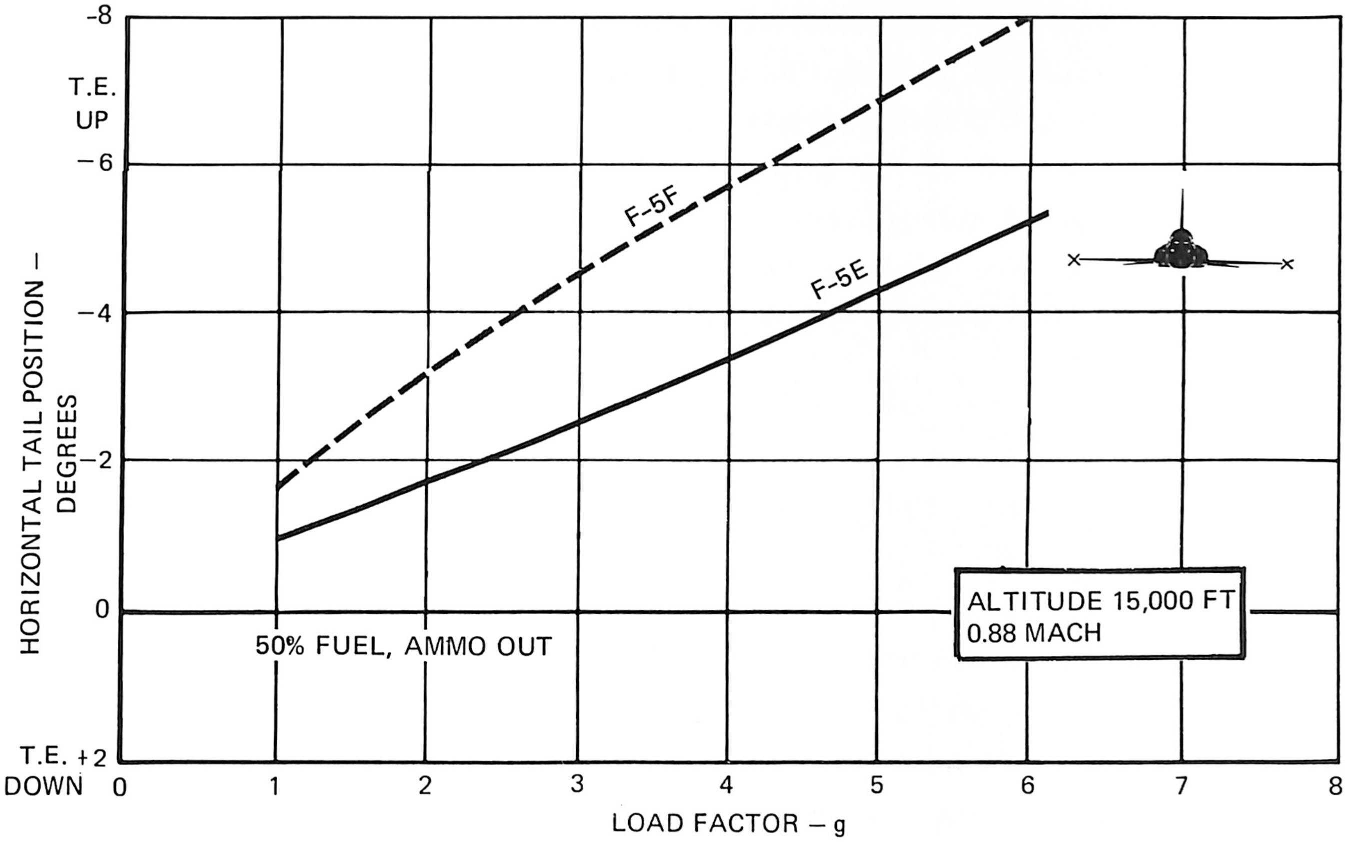


FIGURE 3-5. HORIZONTAL TAIL POSITION VS LOAD FACTOR

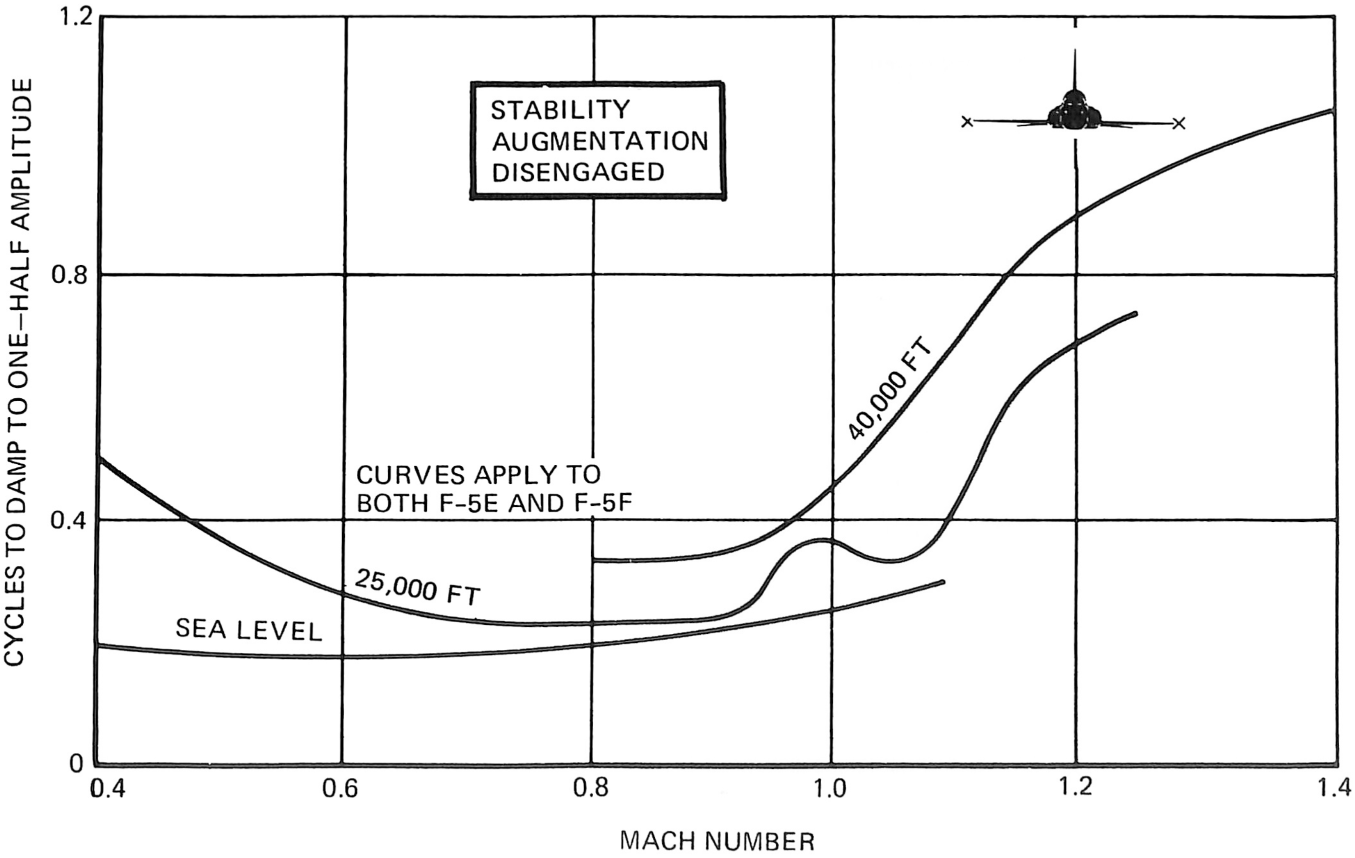


FIGURE 3-6. LONGITUDINAL SHORT PERIOD DAMPING

F-5's and also against high performance Mach 2 aircraft. Precision gun attack tracking was demonstrated well into the buffet region. Results of research flight programs, such as the "Effect of Buffet Intensity on Precision Tracking Program," conducted by NASA Edwards, indicate that buffet onset and even buffet intensity have only very small effect on the pilot's ability to track. The primary influences, as demonstrated in these programs, are the basic aircraft handling qualities in the longitudinal and lateral-directional modes, which in the F-5E/F are excellent.

### Secondary Trim Effects

The wing leading and trailing edge flaps can be used at speeds well into the transonic region (to 0.95 Mach) to improve load factor capability for maneuvering and to improve cruise performance. Longitudinal trim changes due to actuation of the flaps for these modes are minimal, due to the flap-to-horizontal-tail interconnect. The effects of cruise or maneuvering flap settings on the longitudinal stability characteristics are small. Trim changes during afterburner operation are also negligible. Speedbrake extension generally induces a small pitching moment which may require some slight retrim over and above that given by the interconnect.

### Lateral-Directional Characteristics

Good lateral-directional stability is maintained both statically and dynamically. Yaw mode augmentation is not necessary for safe flight, but, as in the case of longitudinal short period characteristics, damping is improved when the augmentation system is engaged.

Roll performance within the high-speed region is excellent. A bank angle well in excess of 120 degrees can be attained in one second, as indicated by the curves in Figure 3-7. No adverse yaw characteristics exist, and inertial coupling between the longitudinal and lateral-directional modes is mild, as shown in the F-5E flight test roll time history, Figure 3-8. F-5F results will be similar.

## SPIN CHARACTERISTICS

The F-5 is spin resistant. Entry into a spin can only be induced by deliberate abnormal control inputs. Oscillations about all three aircraft axes characterize the incipient phase of the spin entry thus making detection of the incipient spin a relatively simple matter. The developed spin mode is flat and erect and may vary from smooth

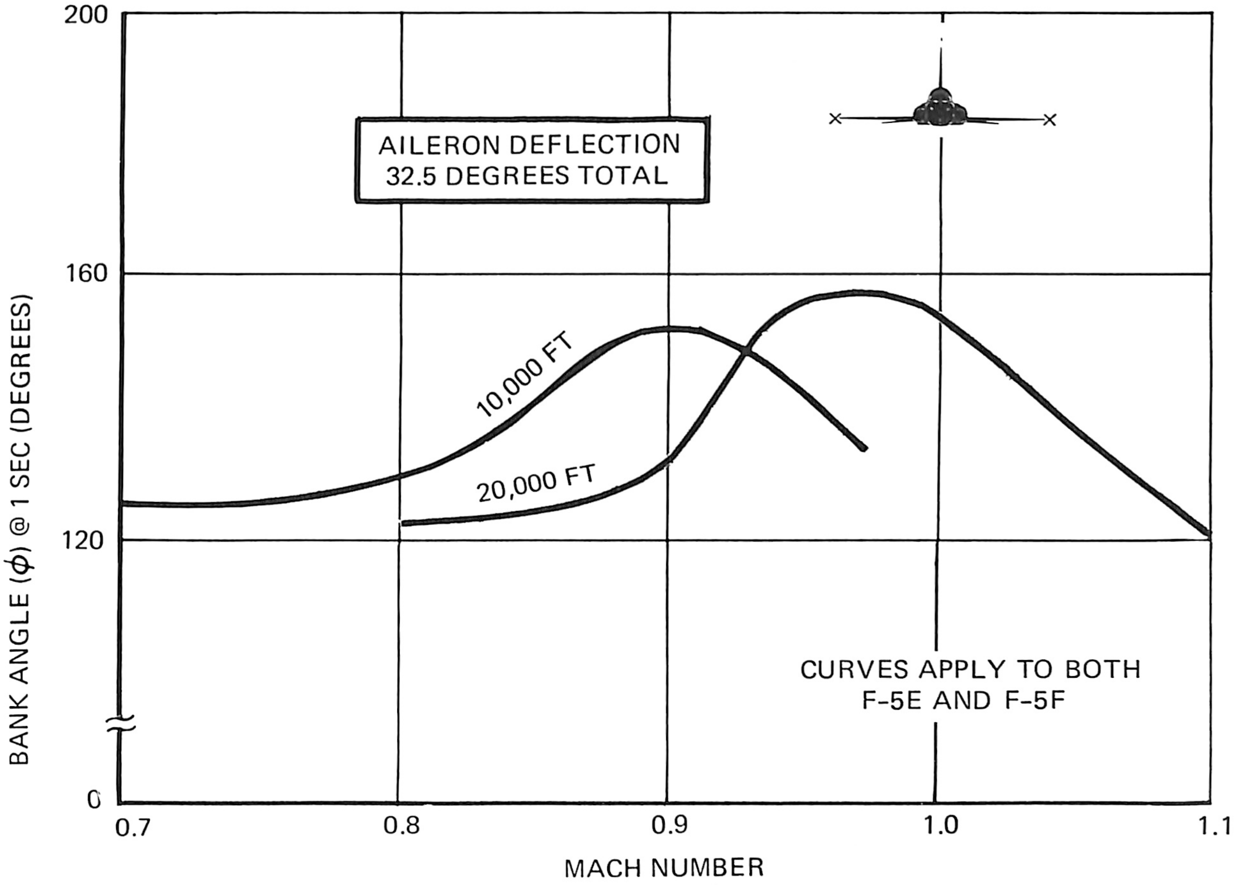


FIGURE 3-7. ROLL PERFORMANCE

to highly oscillatory about all three axes. Inverted spins cannot be sustained. The recommended recovery controls are the same for both the developed and the incipient stages; full aileron in the spin direction, and full rudder against the spin.

### With Launcher Rails

Removal of AIM-9 Sidewinder missiles from the wingtips of the airplane has only a small effect on the static longitudinal and lateral-directional stability. Dynamic characteristics for both the longitudinal short period and lateral-directional modes are essentially the same as those for the AIM-9 missile configuration.

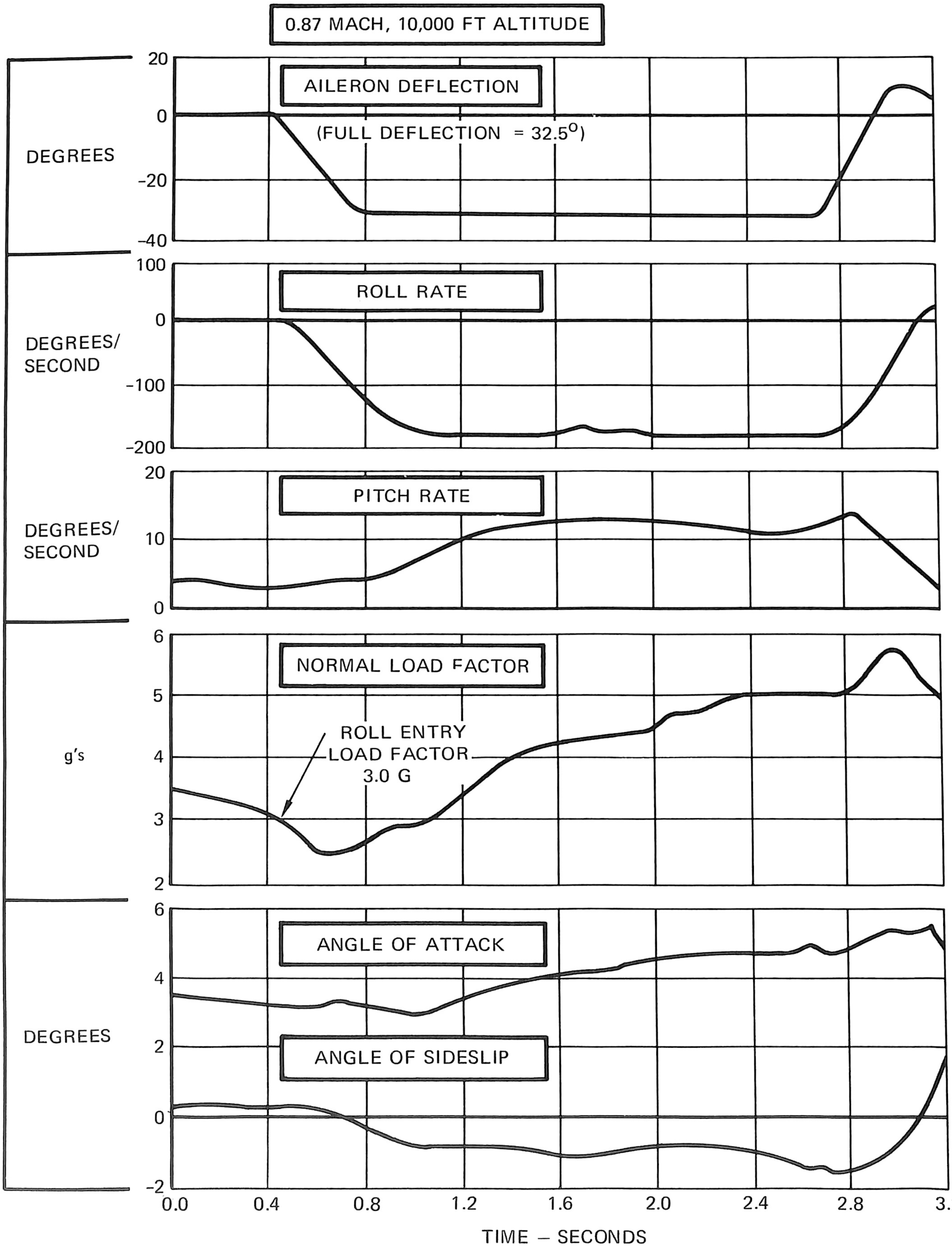


FIGURE 3-8. F-5E ROLL TIME HISTORY LAUNCHER-RAIL CONFIGURATION (360-DEGREE ROLL COUPLING CHARACTERISTICS)

## FLIGHT CHARACTERISTICS WITH EXTERNAL STORES

F-5E flight test results indicate that external stores will not noticeably alter the spin susceptibility characteristics. In the following paragraphs the flight characteristics of the F-5E/F with external stores are compared with those of the AIM-9 missile configuration discussed above.

### With Inboard Wing Pylon Stores

Of all possible combinations of F-5E/F inboard wing stores (Wing Station 93.5), the unfinned BLU 1/B napalm bombs have the greatest effect on handling qualities. With these stores installed, static stability decreases slightly. The one-g stick force variation with airspeed is similar to that for the launcher-rail configuration as are the maneuvering stick force variations with Mach number and load factor. The stick force gradient magnitude is comfortable, but slightly lighter than for the launcher-rail configuration.

Dynamic stability is still positive in both the longitudinal and lateral-directional modes, although the damping ratio is slightly lower. Satisfactory handling qualities are experienced with the augmentation system inoperative, but use of stability augmentation improves the damping ratios. Since the empty pylons do not adversely affect flight characteristics, aircraft handling qualities following ejection of the napalm bombs are essentially the same as for the launcher-rail configuration.

### With Four Underwing Stores

The F-5E/F continues to exhibit satisfactory handling qualities with four underwing stores. The store inertias affect the aircraft flight characteristics but not so much as to reduce airplane stability to any appreciable extent.

Figure 3-9 presents the high speed longitudinal stability data for the airplanes with four underwing stores and AIM-9 missiles at altitudes of 15,000 and 25,000 feet. Positive static stability prevails throughout the entire region, and the trim changes are mild. The curves cover the normal airspeed range for this configuration.

Figure 3-10 presents the stick force buildup with load factor for the same four-store configuration at 0.80 Mach number and 25,000 feet. Note the smoothness of the curves and the complete absence of any stick force reversals.

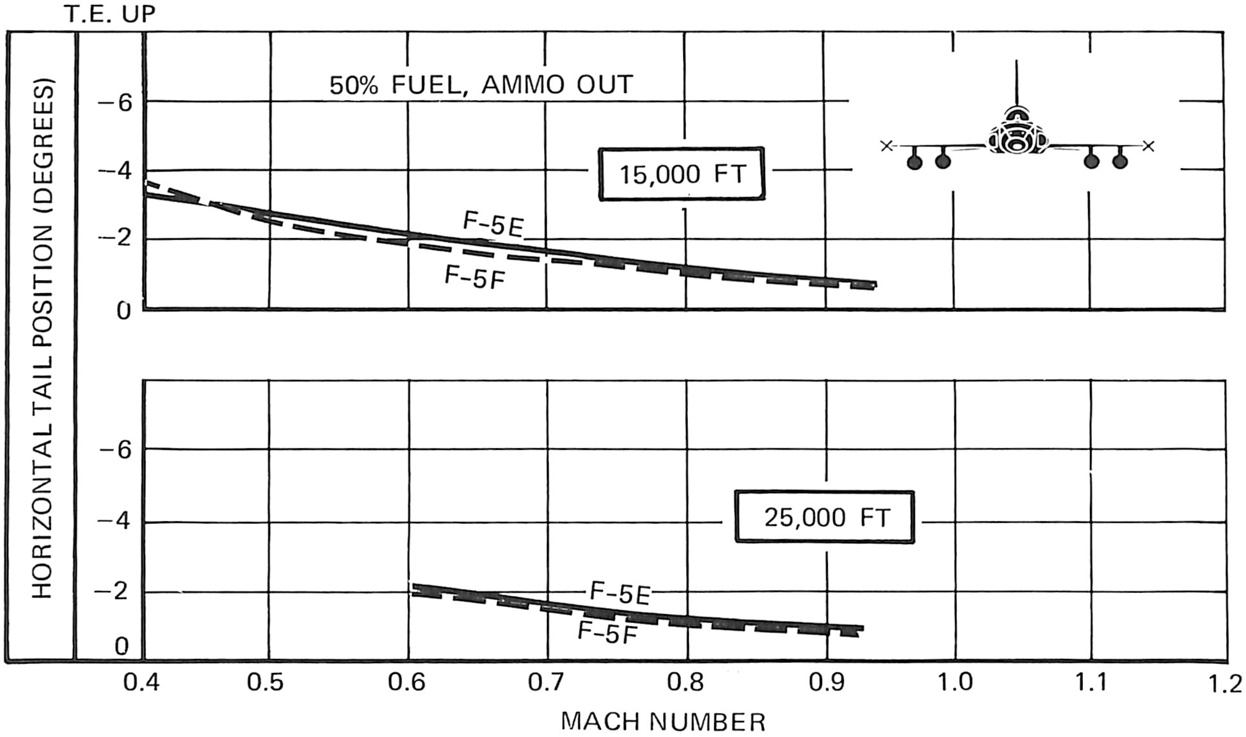


FIGURE 3-9. LONGITUDINAL STABILITY WITH FOUR UNDERWING STORES

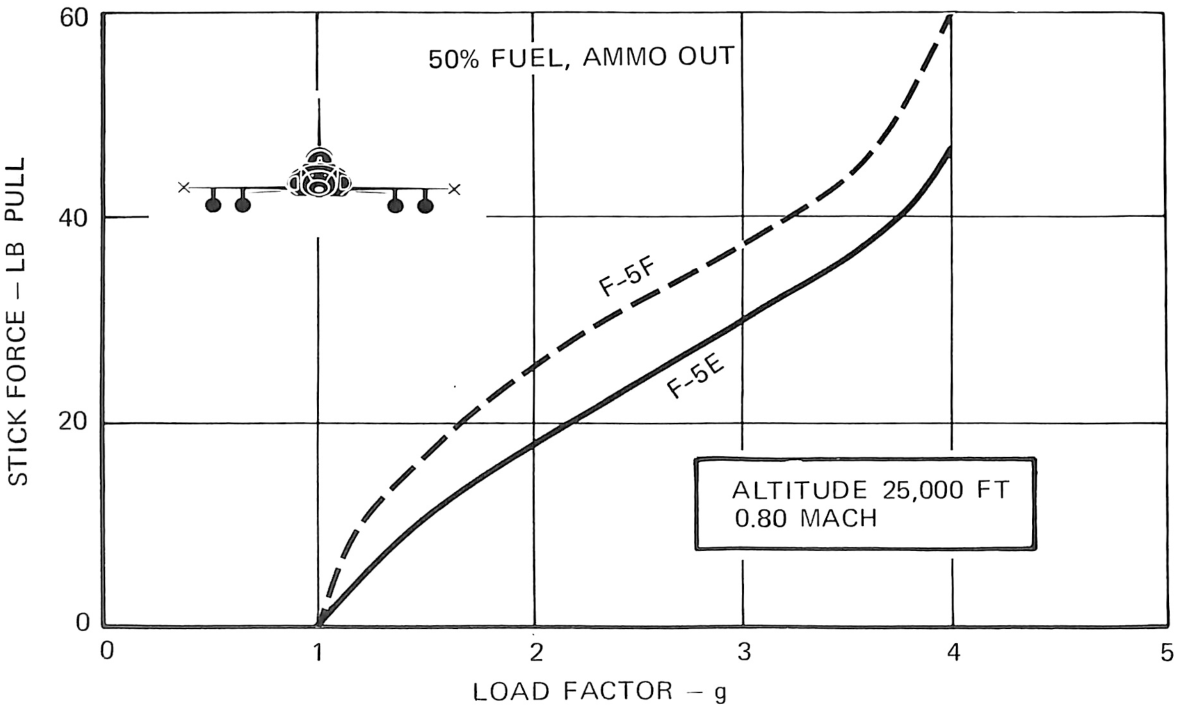


FIGURE 3-10. STICK FORCE VS LOAD FACTOR WITH FOUR UNDERWING STORES

Figure 3-11 presents the variation of horizontal tail position versus load factor for the same configuration. As was noted for the AIM-9 missiles configuration, the tail deflection variation is smooth and completely free from any undesirable characteristics.

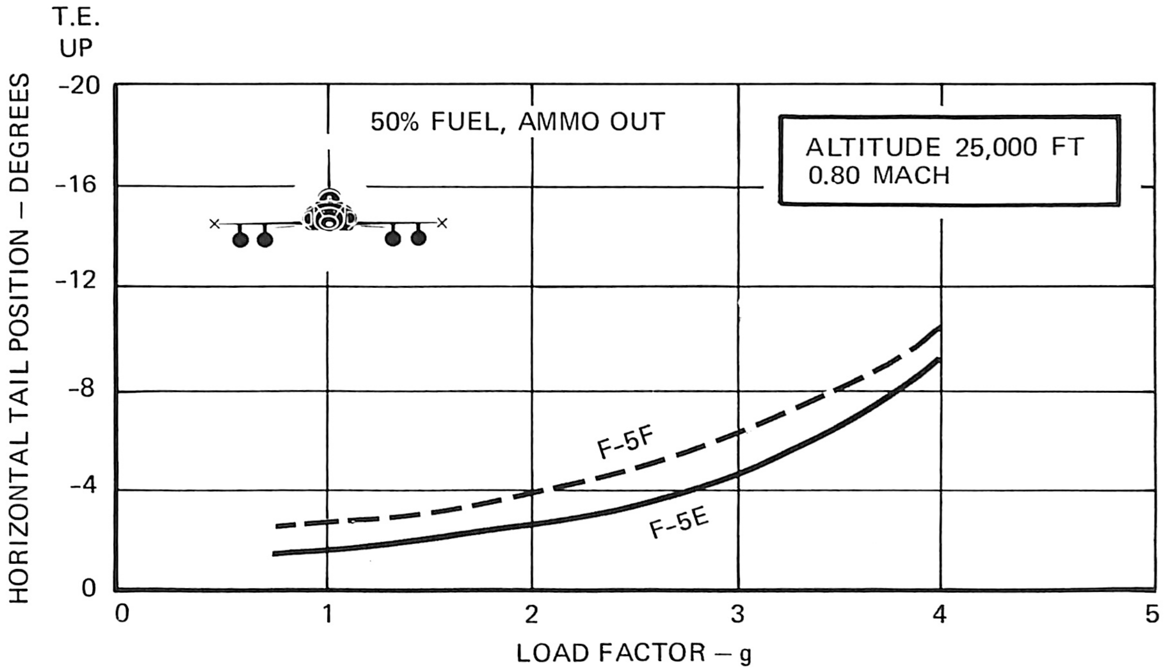


FIGURE 3-11. HORIZONTAL TAIL POSITION VS LOAD FACTOR WITH FOUR UNDERWING STORES

Installation of the outboard stores does increase the roll inertia, which reduces the roll acceleration for full-aileron rolls, but sufficient aileron power remains for all flight maneuvers and available trim to handle any asymmetric condition with outboard wing pylon stores is more than sufficient at all times.

### With Centerline Store

Aerodynamic effects of the centerline store on the handling qualities of the aircraft are very small. The aircraft retain positive directional stability at all times but with a slight decrease in magnitude.

The inertia of a heavy centerline store affects aircraft flight characteristics, and the centers of gravity of the aircraft are moved forward slightly increasing the longitudinal stick forces. However the resulting forces are not uncomfortable. Longitudinal damping decreases slightly but still remains at satisfactory levels, and the use of pitch augmentation improves the damping characteristics.

The Dutch Roll mode also exhibits lower damping with the centerline store, but stability augmentation maintains a satisfactory weapons platform. The effect of the centerline store on roll response is small.

## Air-to-Ground Capability

The F-5A has demonstrated excellent air-to-ground gun firing and weapons delivery capability by winning numerous competitions in Pacific and NATO countries and in the USA. The dynamic response of the aircraft to small inputs of horizontal tail, aileron or rudder is considered paramount among the stability and control characteristics that contribute to this high level of store delivery accuracy. The same standards of known stability and control parameters responsible for the excellent F-5A/B flying qualities in the air-to-ground mode are incorporated in the F-5E/F.

# SECTION 4

# AIRCRAFT SYSTEMS DESCRIPTION

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# SECTION 4

# AIRCRAFT SYSTEMS DESCRIPTION

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This section contains summary descriptions of the F-5E/F aircraft systems. The design and integration of these systems reflect the technical, manufacturing, operational and logistics experience gained with the F-5/T-38 family of aircraft. Ease of maintenance was emphasized in the design. Maintenance access doors comprise approximately 25 percent of the fuselage surface area. System components have been oriented such that 90 percent of the maintenance operations can be accomplished at ground level. Inboard profiles illustrating the arrangement of systems and equipment for the F-5E and F-5F are presented in Figures 4-1 and 4-2.

## AIRFRAME STRUCTURE

The descriptions of the F-5E/F basic structures shown in Figures 4-3 and 4-4 are divided into the fuselage and wing. The empennage is included in the fuselage description.

### Fuselage Structure

The fuselage is a conventional semi-monocoque structure consisting of stressed skins supported by frames, longerons, and bulkheads. The basic structural material is aluminum alloy. Magnesium skins, coated to prevent corrosive action, are used in some areas. Steel and titanium are used in high-temperature areas.

The fuselage consists of three major subassemblies: forward, center, and aft. The forward and center fuselage subassemblies are joined at Fuselage Station 284.0. The aft fuselage section is removable at Canted Fuselage Station 520.075 to enable engine replacement in the field. The vertical stabilizer is an integral part of the center fuselage, and the horizontal stabilizer is bearing-mounted to the side panels of the aft fuselage.

F-5E Forward Fuselage. The forward fuselage consists of four structural sections designated as the radome section, equipment bay section, nose landing gear and gun bay section and the cockpit and aft equipment section.

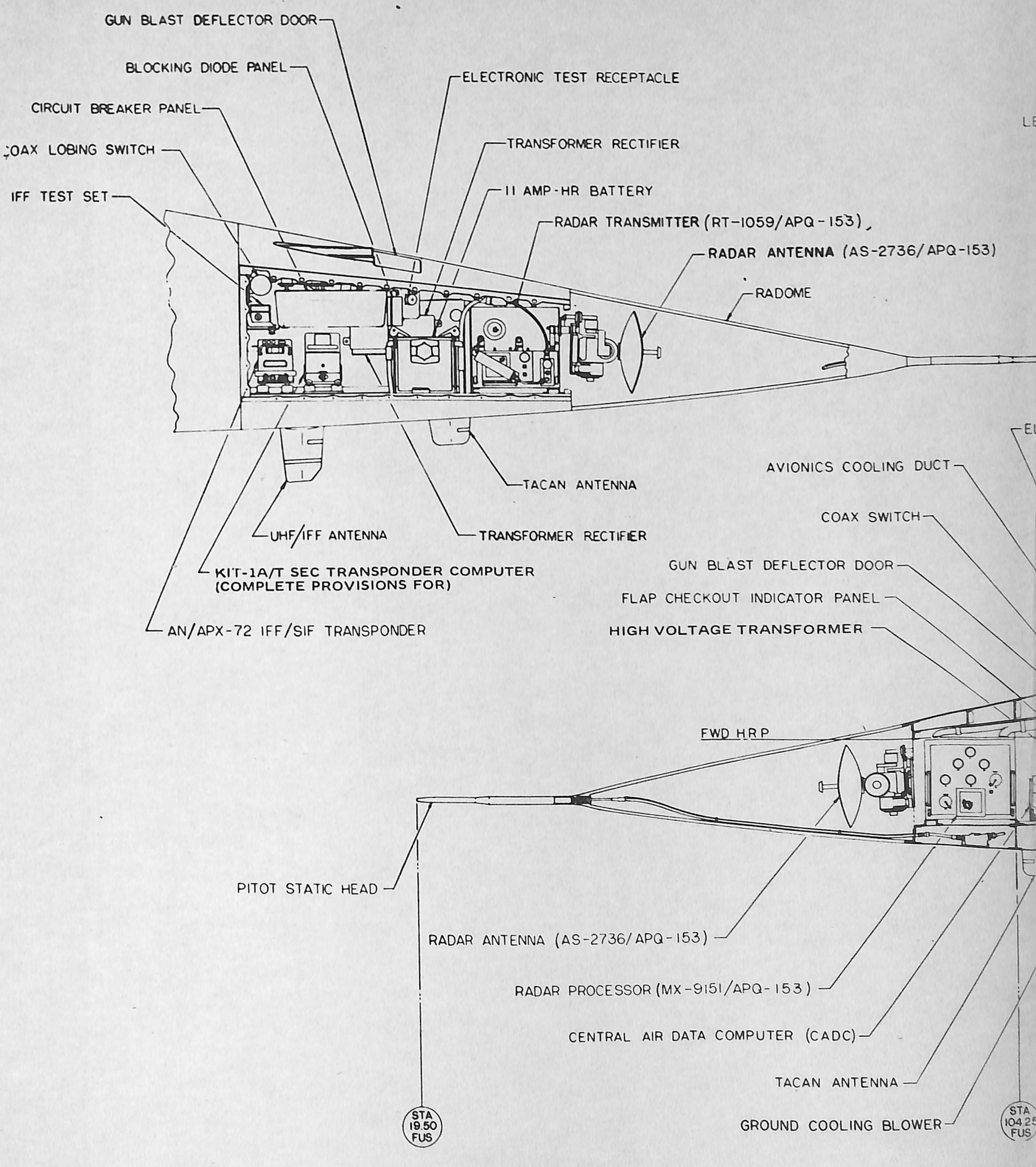
GUN BLAST DEFLECTOR DOOR
BLOCKING DIODE PANEL
ELECTRONIC TEST RECEPTACLE
CIRCUIT BREAKER PANEL
COAX LOBING SWITCH
TRANSFORMER RECTIFIER
IFF TEST SET
11 AMP-HR BATTERY
RADAR TRANSMITTER (RT-1059/APQ-153)
RADAR ANTENNA (AS-2736/APQ-153)
RADOME
LE
TACAN ANTENNA
UHF/IFF ANTENNA
TRANSFORMER RECTIFIER
KIT-1A/T SEC TRANSPONDER COMPUTER (COMPLETE PROVISIONS FOR)
AN/APX-72 IFF/SIF TRANSPONDER
EL
AVIONICS COOLING DUCT
COAX SWITCH
GUN BLAST DEFLECTOR DOOR
FLAP CHECKOUT INDICATOR PANEL
HIGH VOLTAGE TRANSFORMER
FWD HRP
PITOT STATIC HEAD
RADAR ANTENNA (AS-2736/APQ-153)
RADAR PROCESSOR (MX-9151/APQ-153)
CENTRAL AIR DATA COMPUTER (CADC)
TACAN ANTENNA
GROUND COOLING BLOWER
STA 19.50 FUS
STA 104.25 FUS

FIGURE 4-1. F-5E INBOARD PROFILE

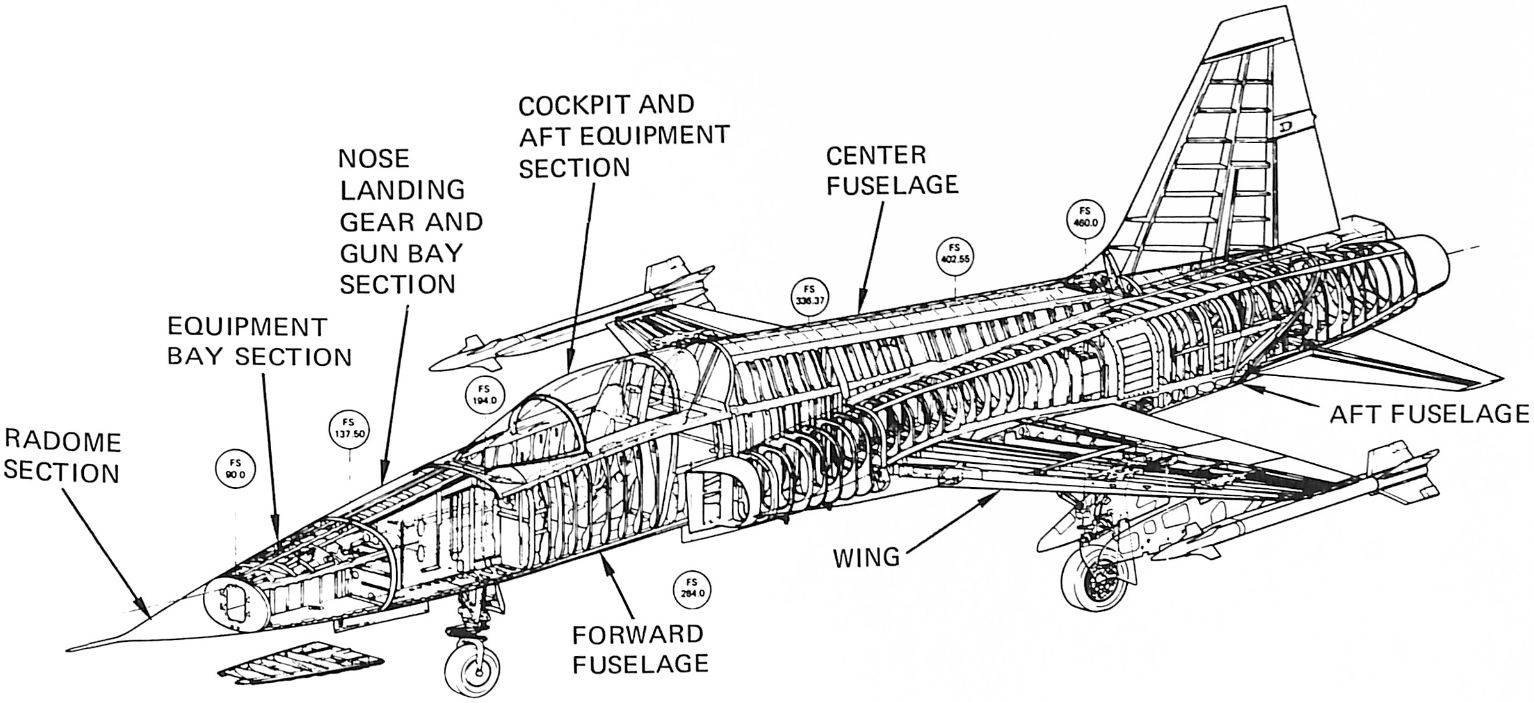
COCKPIT AND AFT EQUIPMENT SECTION
NOSE LANDING GEAR AND GUN BAY SECTION
CENTER FUSELAGE
FS 460.0
FS 402.55
FS 336.37
EQUIPMENT BAY SECTION
FS 194.0
FS 137.50
RADOME SECTION
FS 90.0
AFT FUSELAGE
WING
FS 284.0
FORWARD FUSELAGE

FIGURE 4-3. F-5E AIRFRAME STRUCTURAL DIAGRAM

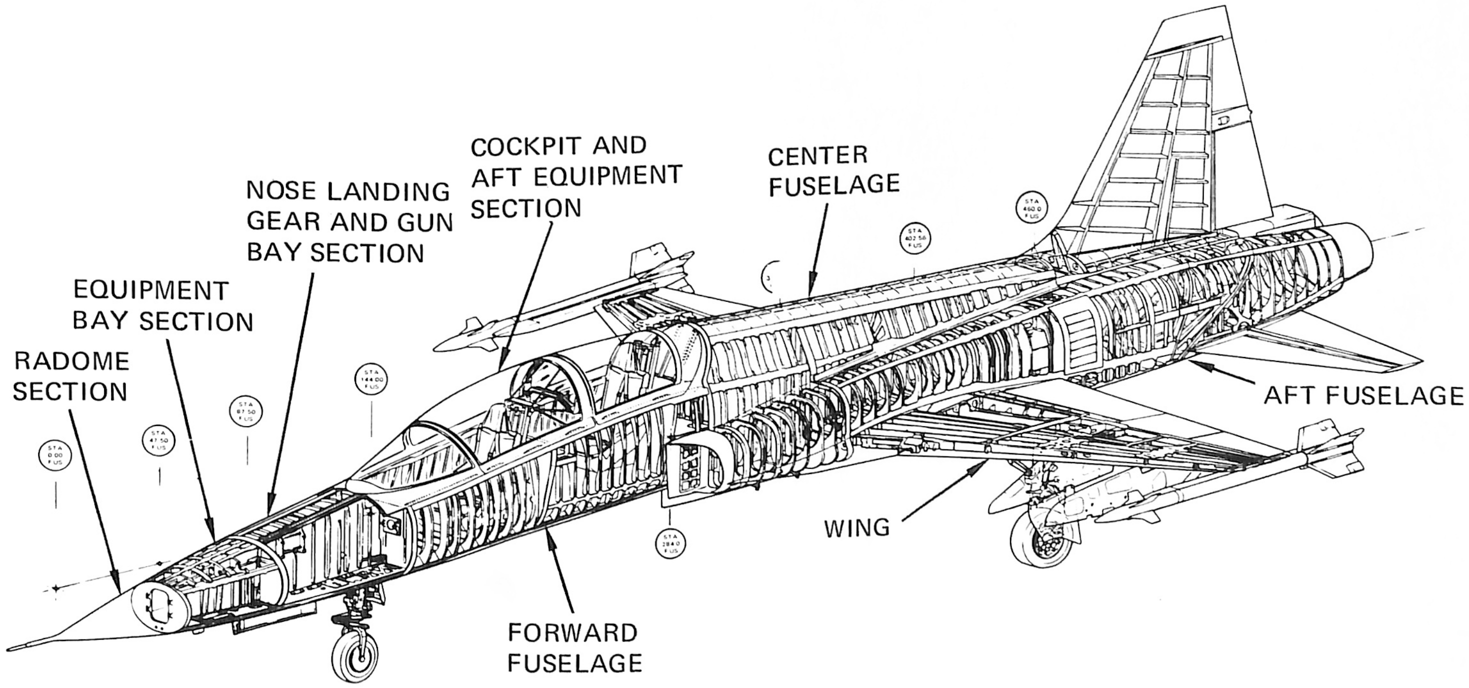
COCKPIT AND AFT EQUIPMENT SECTION
CENTER FUSELAGE
NOSE LANDING GEAR AND GUN BAY SECTION
STA 460.0 FUS
STA 402.56 FUS
EQUIPMENT BAY SECTION
RADOME SECTION
STA 144.00 FUS
STA 87.50 FUS
STA 47.50 FUS
STA 0.00 FUS
AFT FUSELAGE
WING
STA 284.0 FUS
FORWARD FUSELAGE

FIGURE 4-4. F-5F AIRFRAME STRUCTURAL DIAGRAM

The F-5E radome section, shown in Figure 4-5, is a reinforced plastic shell structure extending forward from FS 90.0. It is retained by four tension bolts and two shear pins which are accessible through the equipment bay access doors. The radome is a continuous unjointed tapered glass-laminated shell that is anti-static and rain-erosion coated. In addition, it is lightning-protected by segmented diverter strips on the outside surface which provide an exterior ionized path from radome to aircraft structure. The radome section supports the pitot-static system boom. Access for pitot lines disconnect is provided through the lower door in the adjacent structure.

The F-5E equipment bay section, Figure 4-5, extends from FS 90.0 to FS 137.5 and houses avionics equipment. Access is provided through two large nonstructural doors, one on each side of the aircraft.

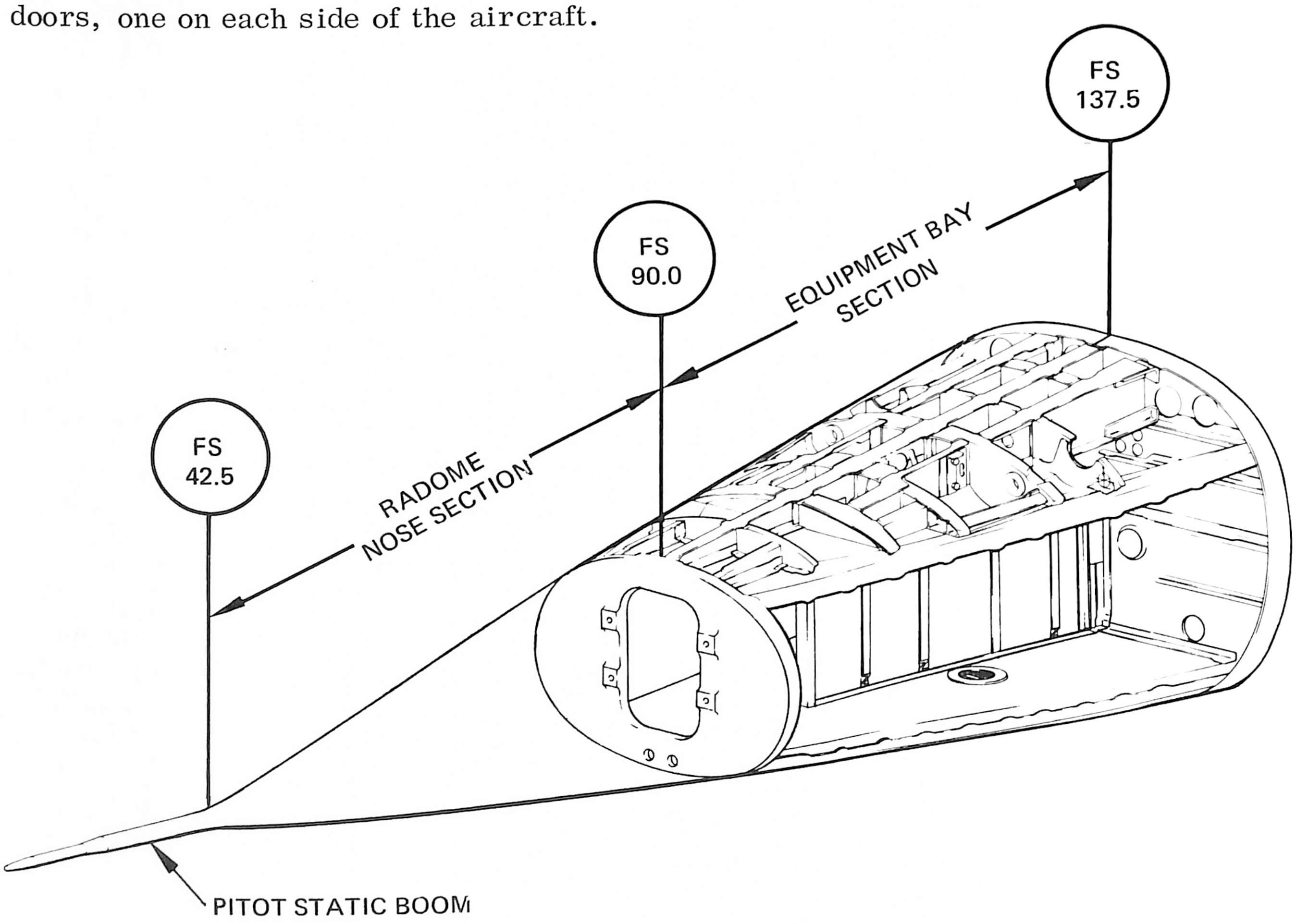

FIGURE 4-5. F-5E RADOME AND EQUIPMENT BAY SECTIONS

The F-5E nose landing gear and gun bay section shown in Figure 4-6 extends from FS 137.5 to FS 194.0. Two longitudinal/vertical shear webs divide the bay into three compartments. The center compartment houses the nose gear in the stowed position and the two outer bays house two 20mm, M-39 guns and ammunition. Four large nonstructural doors are provided for gun bay access.

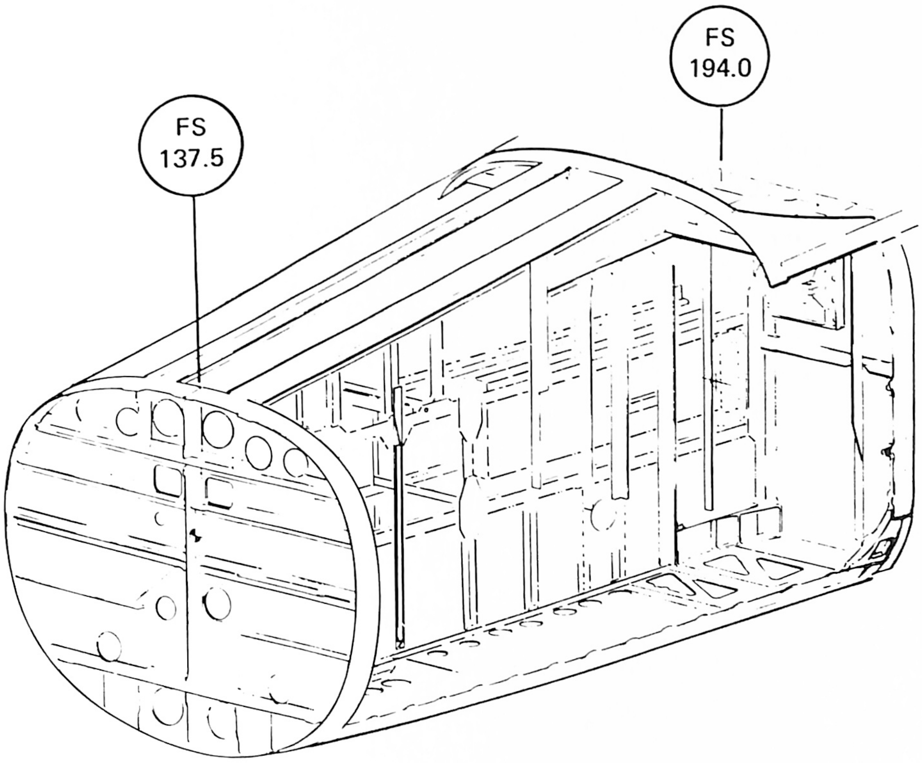

**FIGURE 4-6. F-5E NOSE LANDING GEAR AND GUN BAY SECTION**

The F-5E cockpit and aft equipment bay shown in Figure 4-7 extends from FS 194 to FS 284. It contains all crew accommodations, aircraft and system controls, windshield, canopy and associated mechanism, air-conditioning unit and miscellaneous avionics equipment. Flight control mechanisms are mounted below the cockpit floor with access through quick-removal lower fuselage surface doors.

The F-5E windshield is designed to resist penetration of a four-pound bird at aircraft flight speeds up to 400 knots. It is fabricated from a 0.71-inch thick monolithic stretched-acrylic transparency retained by a one-piece magnesium casting. The canopy is made from monolithic, biaxially stretched acrylic sheet with a finished mean thickness of 0.23 inch and is retained by an aluminum frame.

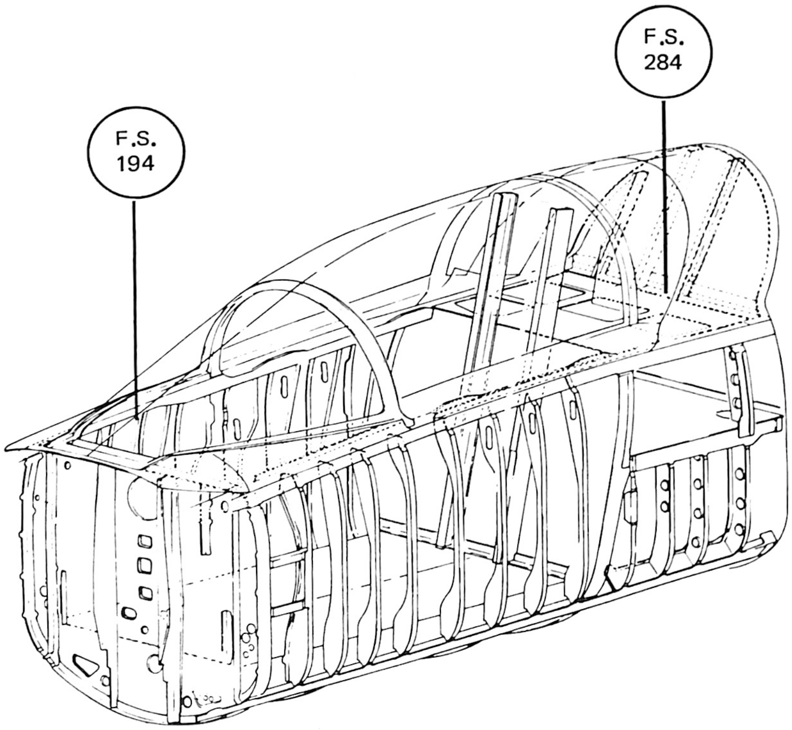
F.S. 284
F.S. 194

FIGURE 4-7. F-5E COCKPIT AND EQUIPMENT SECTION

F-5F Forward Fuselage. The F-5F forward fuselage also consists of four structural sections designated as the radome section and equipment bay section (Figure 4-8), nose landing gear and gun bay section (Figure 4-9), and the cockpit and aft equipment section (Figure 4-10). The F-5F radome section is identical to the F-5E. The

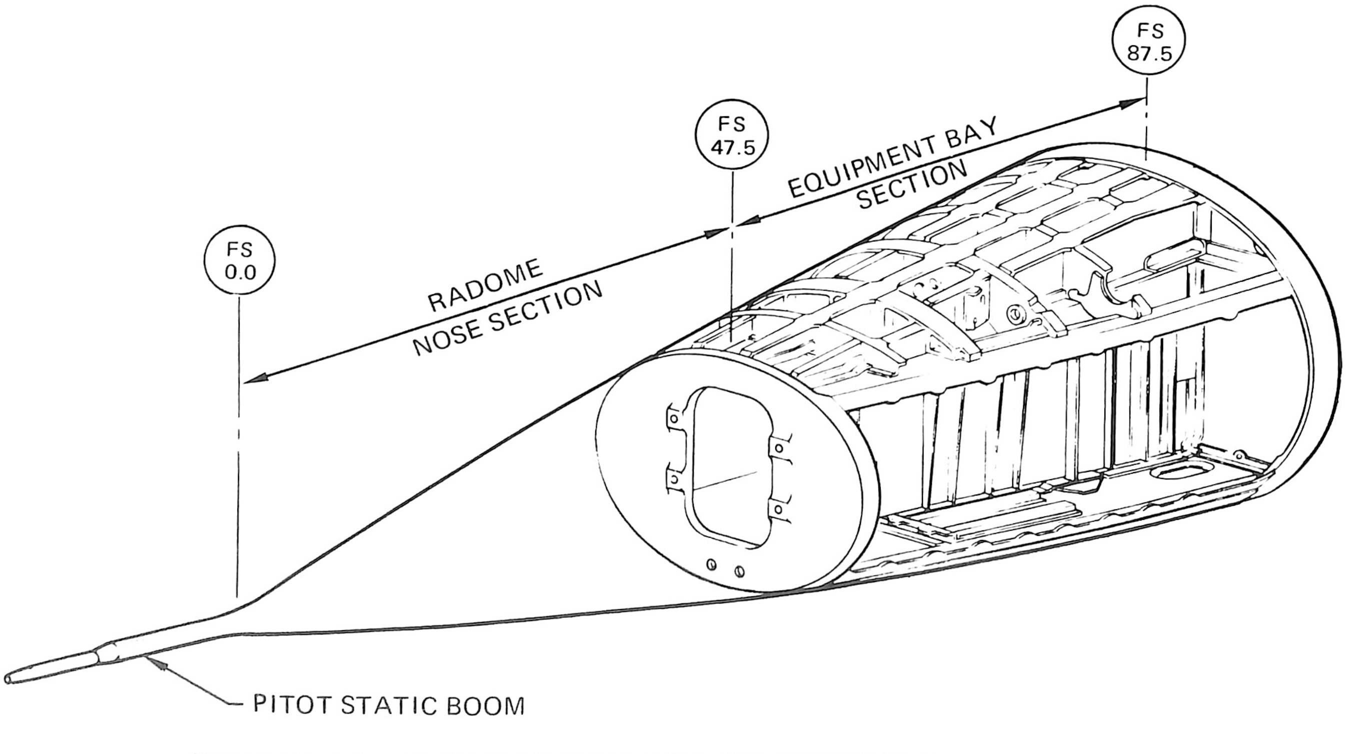
FS 87.5
FS 47.5
EQUIPMENT BAY SECTION
FS 0.0
RADOME NOSE SECTION
PITOT STATIC BOOM

FIGURE 4-8. F-5F RADOME AND EQUIPMENT BAY SECTIONS

remainder of the forward fuselage is a new design for the F-5F; however, a high degree of commonality exists with the F-5B in the cockpit and enclosure area.

The F-5F equipment bay section (Figure 4-8) extends from FS 47.5 to FS 87.5 and houses avionics equipment. Access is provided through two large nonstructural doors, one on each side of the aircraft.

The F-5F nose landing gear and gun bay section extends from FS 87.5 to FS 144 (Figure 4-9). Two longitudinal/vertical shear webs divide the bay into three compartments. The center compartment houses the nose gear in the stowed position. The left hand compartment houses a 20mm M-39 gun and ammunition, and has two large nonstructural doors for access. The right-hand compartment houses avionics equipment and the liquid oxygen bottle and converter and has one large nonstructural door for access.

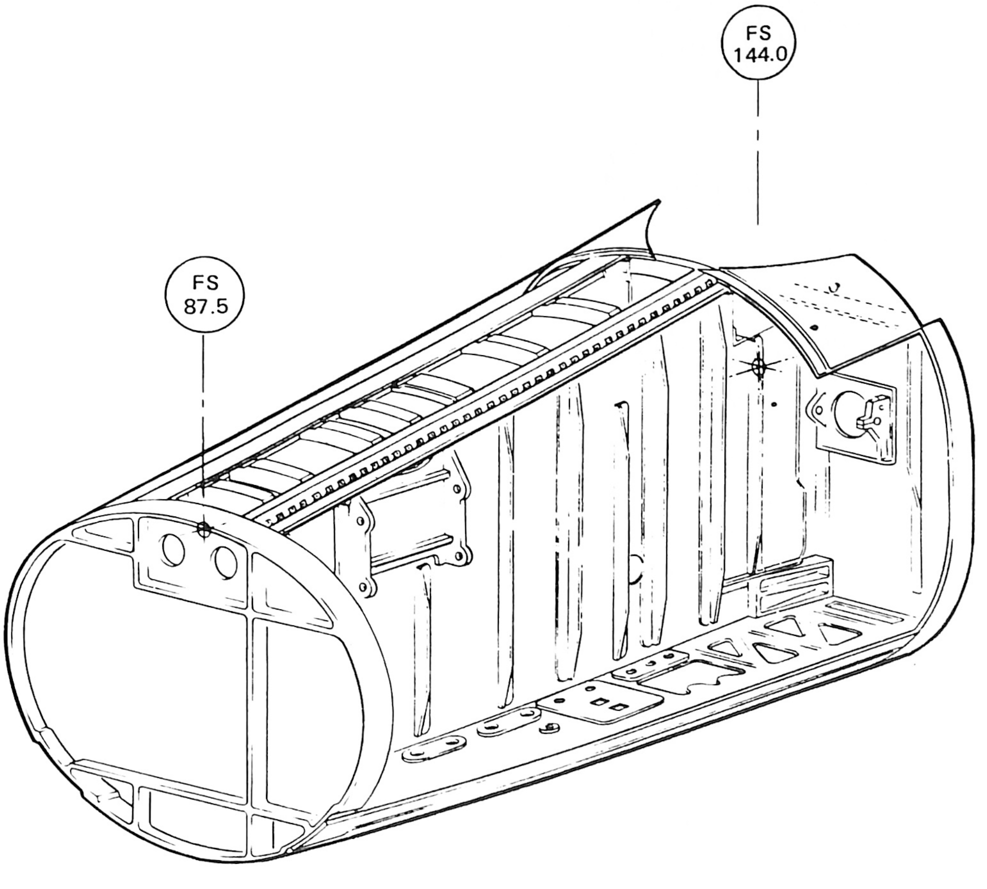

FIGURE 4-9. F-5F NOSE LANDING GEAR AND GUN BAY SECTION

The F-5 cockpit and aft equipment section, Figure 4-10, extends from FS 144 to FS 284, and is similar to the F-5B. It contains all crew accommodations, aircraft and systems controls, windshield, canopies and associated mechanisms, air-conditioning unit and avionics equipment. Flight control mechanisms are mounted below the cockpit floor with access through quick-access lower fuselage surface doors. The structure underneath the pilots' floor is similar to the F-5B but is built to a revised mold line and is modified to accommodate system installations compatible with the F-5E center fuselage systems.

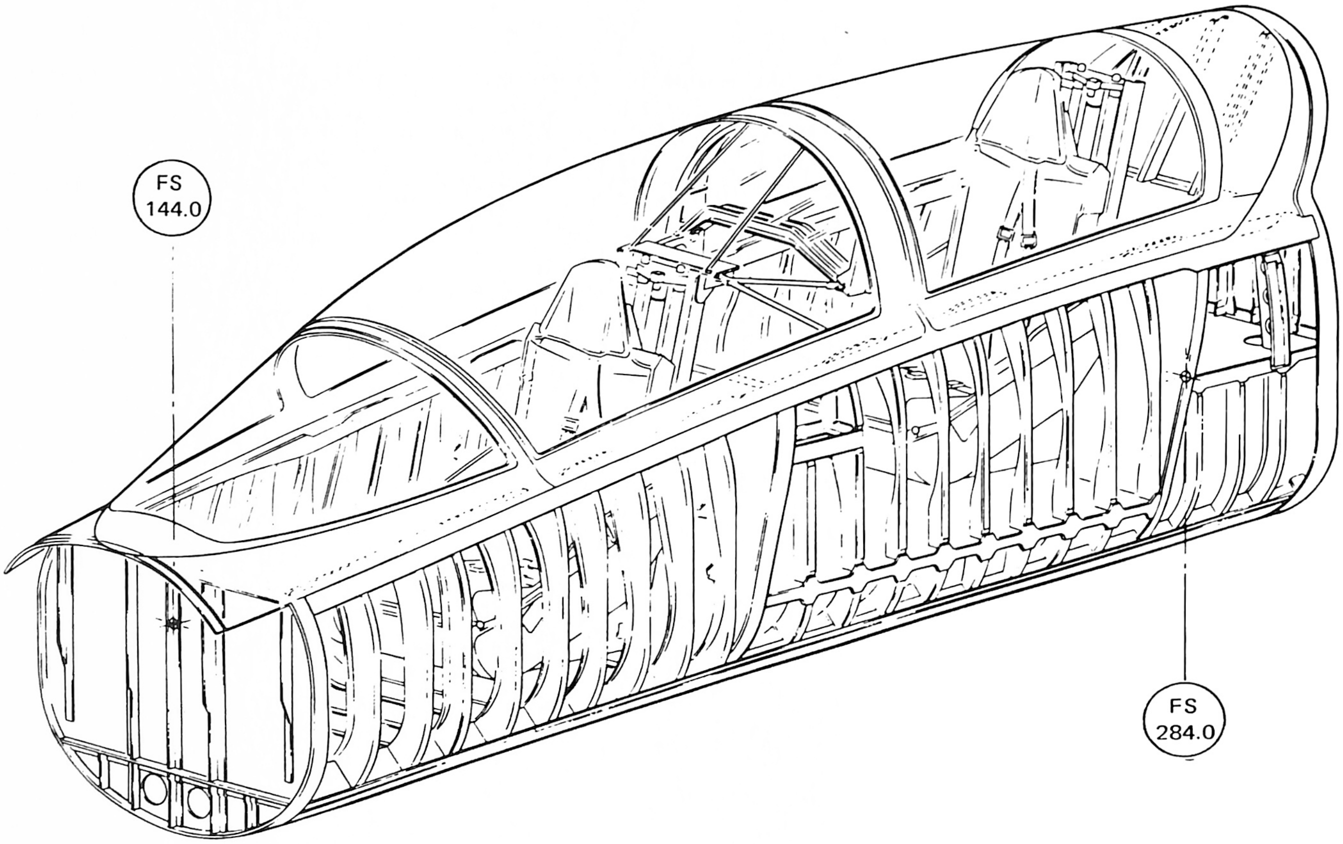

FIGURE 4-10. F-5F COCKPIT AND AFT EQUIPMENT SECTION

The F-5F cockpit area is enclosed by a forward windshield and two canopies. An aft fixed windshield is provided between the two crew member compartments. The canopies and aft windshield are identical to the F-5B. The forward windshield is designed to withstand impact of a four-pound bird at aircraft speeds up to 350 knots. It is fabricated from a 0.60-inch-thick stretched-acrylic transparency and is retained by a one-piece cast magnesium frame. The frame is similar to the F-5B except for contour differences at the forward end. The aft windshield is a flat 0.40-inch-thick acrylic panel designed to protect the aft crew member from the rocket blast during front seat ejection and from the slipstream in the event of inadvertent front canopy loss. The forward canopy is made from monolithic, biaxially stretched, acrylic sheet with a finished mean thickness of 0.23 inch, and is retained by an aluminum frame. The aft canopy similar in construction but is 0.40 inch thick. The added thickness provides protection from possible front-seat ejection rocket blast. The two bays located directly aft of the rear pilot's seat contain avionics equipment and the air-conditioning unit.

F-5E/F Center Fuselage/Vertical Stabilizer. The F-5E/F center fuselage, Figure 4-11, extends from FS 284 to FS 520.075 (canted). It provides structural support for the two J85-GE-21 engines, the vertical stabilizer, wing, arresting hook, a centerline pylon and the main landing gear doors. Structural provisions are included for attachment of assisted takeoff (ATO) units in the lower center fuselage structure. An ATO rack carrying four KS-1000 ATO bottles with a total thrust of 4000 pounds car be accommodated.

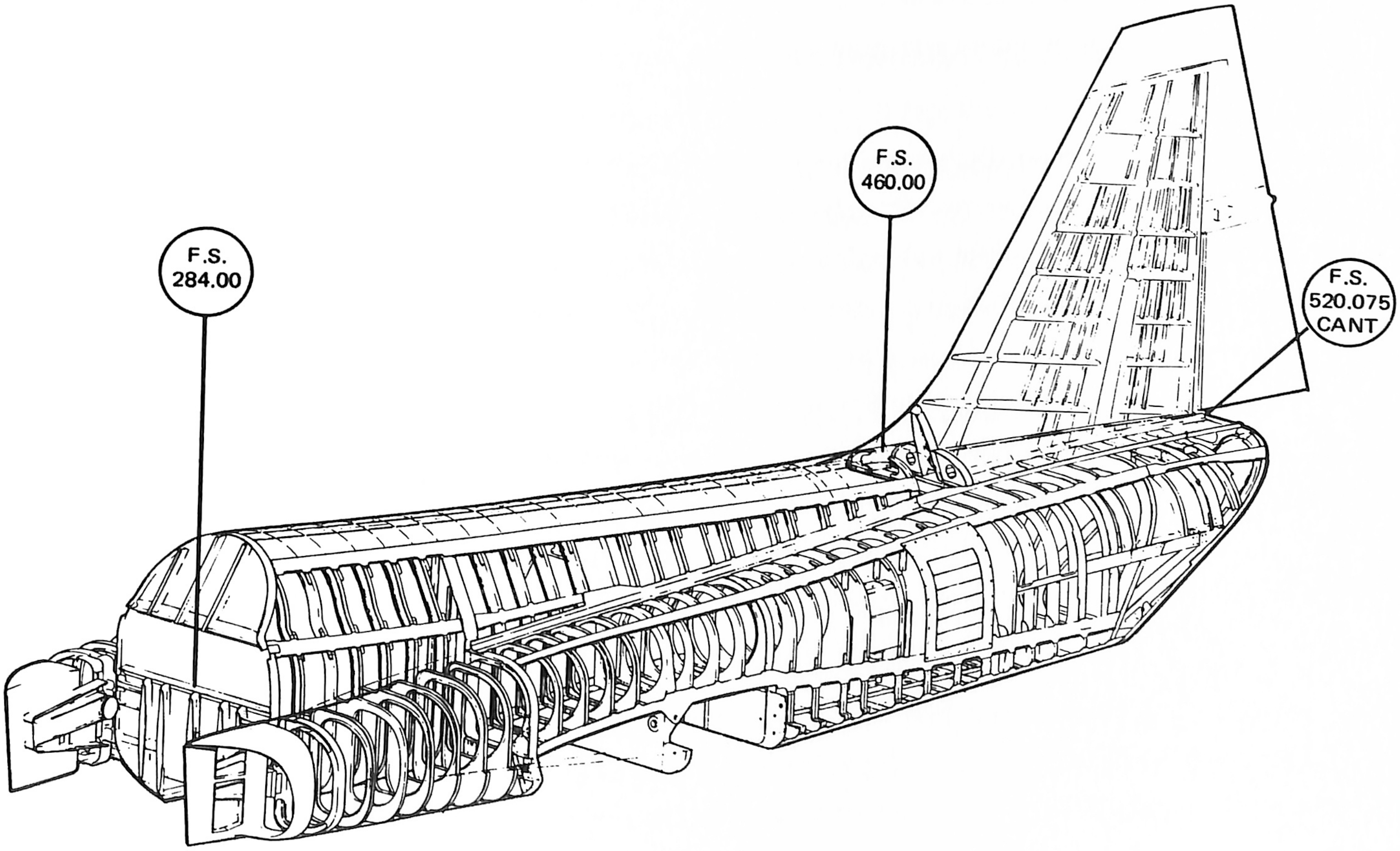

FIGURE 4-11. F-5E/F CENTER FUSELAGE AND VERTICAL STABILIZER

The F-5F center fuselage is similar to the F-5E but incorporates slight modifications Some components at the interface with the forward fuselage are strengthened and some skin thicknesses are increased to support the additional loads imposed by the forward fuselage. The F-5F FS 284.0 bulkhead area has also been changed to reroute the dorsal hot-air duct.

The F-5E/F center fuselage houses the main landing gear wheels, all three internal fuel cells, miscellaneous system components, lines, cables, etc. Four full bulkheads support the three fuel cells. A nonstructural glass laminate dorsal cover that extends the full length of the center fuselage is removable for ready access to engine bleed air lines, fuel vent lines and electric/antenna cables.

The aft portion of the center fuselage contains auxiliary air inlet doors, the forward and aft engine supports, engine accessories and structural tracks to facilitate engine removal. Each engine bay is completely shrouded by titanium fire walls to isolate the engines from each other and from the primary structure. Two spring loaded fire access doors are provided. The auxiliary air inlet doors are discussed in detail in the description of the propulsion system.

The F-5E/F vertical stabilizer is permanently attached to the center fuselage. It is a single-spar aluminum alloy structure with honeycomb leading- and trailing-edge sections. The vertical stabilizer provides structural mounts for the rudder. The rudder assembly is a single-spar, full-depth aluminum honeycomb structure with a torque tube attached to the spar. The tip of the vertical stabilizer is a laminated fiberglass assembly.

F-5E/F Aft Fuselage/Horizontal Stabilizer. The F-5E/F aft fuselage extends aft from FS 520.075 (canted). The structure, shown in Figure 4-12, consists of the basic fuselage structure, a drag chute compartment, engine cooling air ejectors, the horizontal stabilizer, and titanium engine shrouds (omitted from the figure for pictorial clarity). The complete assembly is attached to the center fuselage by bolts and shear pins to permit easy detachment for engine removal.

The basic structure consists of titanium longerons, aluminum alloy and titanium skins, and aluminum and titanium built-up frames. The engine cooling air ejectors are made of Hastelloy X material to withstand the elevated temperatures.

The horizontal stabilizer structure consists of a single spar and closing-rib structure with full-depth aluminum alloy honeycomb for added stiffness and skin stability. The single spar converges into a cylindrical axle (torque tube) that extends through the aft fuselage assembly and is supported by bearings on the outboard sides of the fuselage.

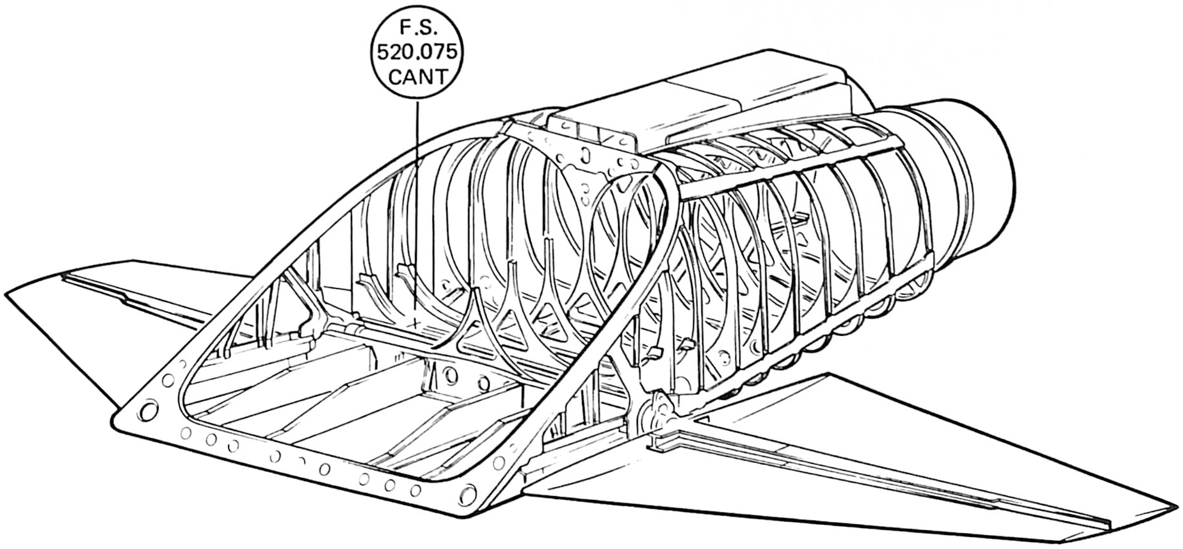

FIGURE 4-12. F-5E/F AFT FUSELAGE AND HORIZONTAL STABILIZER

The F-5F torque tube is strengthened by increasing the thickness to handle higher loads. The right and left axles are machined to a male/female fitting configuration at the aircraft centerline and are bolted together to secure the surfaces. A spline-type splice tube retains the bearings and also provides for quick removal of each horizontal surface. The stabilizer is actuated by bellcranks attached to each end of the splice tube. The actuating cylinders remain attached to the bellcranks during aft fuselage removal, which eliminates the need for rerigging the stabilizer control system.

### Wing Structure

The major wing components consist of the main wing box, leading and trailing edge flaps, ailerons, leading edge extension, and speed brakes. The wing contains substructure for the support of the main landing gear and six external store stations (wingtips plus two underwing locations per side). The basic wing structure is shown in Figure 4-13. F-5E and F-5F wings are identical.

Main Wing Box. The main wing box is a multispar, all-aluminum structure except for steel ribs supporting the landing gear and wingtip stores. The main wing skins are machined from plate and extend as single pieces from tip to tip. This single-piece construction eliminates fatigue problems generally associated with splices in the primary bending material. The front spar of the wing box is at the 15-percent chord; the aft spar at the 44-percent chord. Intermediate spars are located at the 21-, 27-, 33-, and 39-percent chords. The rear spar, which forms the aft boundary of the main landing gear wheel well, is at the 66-percent chord. The forward boundary of the main landing gear wheel well is at the 44-percent spar. The landing gear trunnion fitting is machined as an integral part of the rib at Wing Station 73.30.

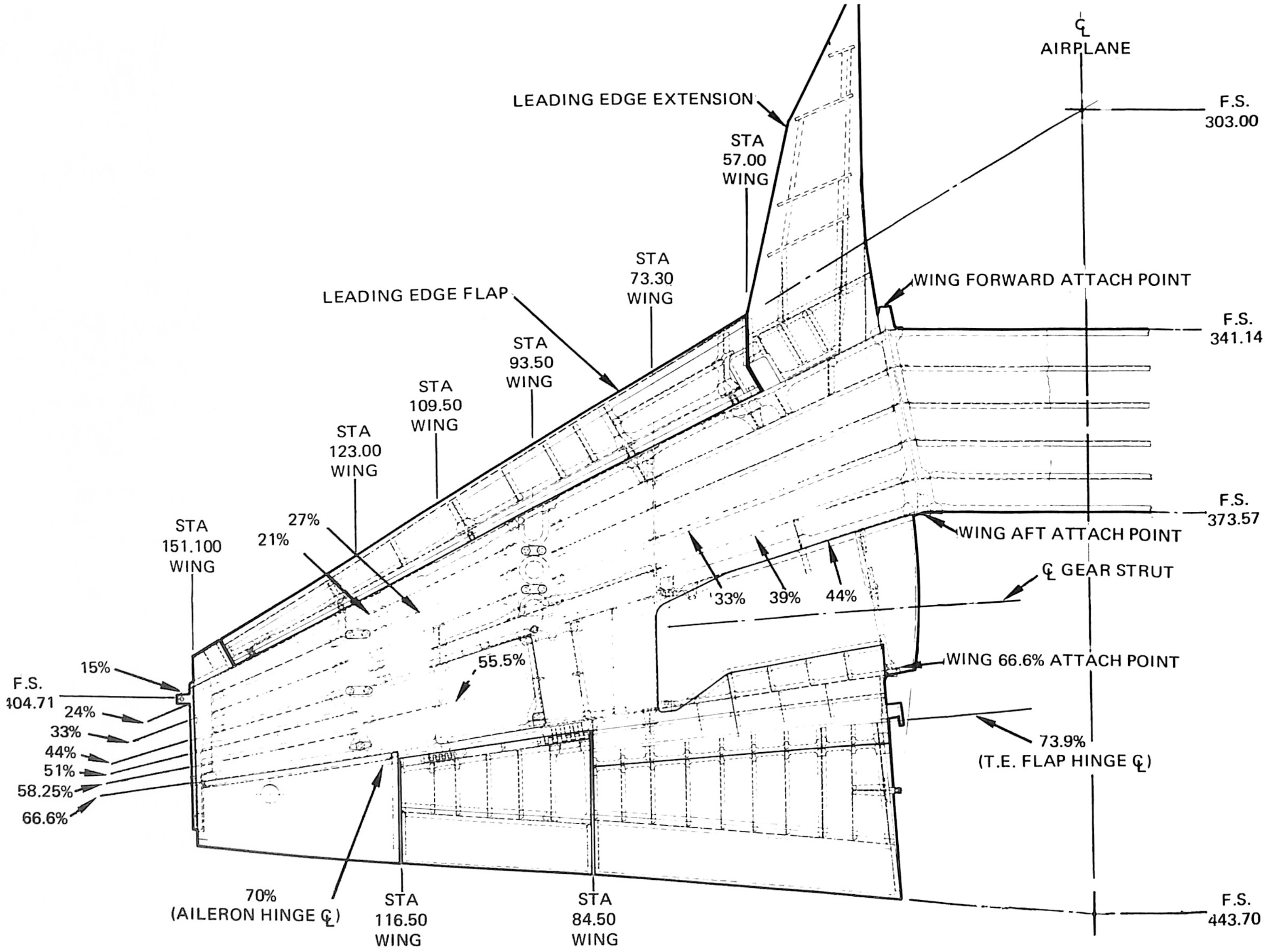
℄ AIRPLANE
F.S. 303.00
LEADING EDGE EXTENSION
STA 57.00 WING
WING FORWARD ATTACH POINT
STA 73.30 WING
LEADING EDGE FLAP
F.S. 341.14
STA 93.50 WING
STA 109.50 WING
STA 123.00 WING
STA 151.100 WING
27%
21%
F.S. 373.57
WING AFT ATTACH POINT
℄ GEAR STRUT
33%
39%
44%
15%
F.S. 404.71
24%
33%
44%
51%
58.25%
66.6%
55.5%
WING 66.6% ATTACH POINT
73.9% (T.E. FLAP HINGE ℄)
70% (AILERON HINGE ℄)
STA 116.50 WING
STA 84.50 WING
F.S. 443.70

FIGURE 4-13. F-5E/F WING STRUCTURE

The wing is attached to the fuselage through six shear-type fittings: two each at the 15-, 44-, and 66-percent spars. The fittings at the 15- and 44-percent spars are integral parts of two canted forged ribs located at the wing-fuselage intersection line.

Pylon attach ribs are incorporated in the wing structure at Wing Stations 93.50 and 123.00. The pylon at Wing Station 93.50 is attached with five bolts and two shear pins. Four bolts and two shear pins are used for the pylon at Wing Station 123.00. Pylon J-hook provisions are incorporated for pylon jettison capability. The pylons are described in the armament subsection of this document. Each wingtip has a structure attachment for either a Sidewinder AIM-9 missile launcher or a 50-gallon fuel tank.

Leading-Edge Flap. The wing is equipped with a maneuvering leading edge flap located forward of the 15-percent chord spar of the main wing box structure. The flap extends outboard from the fixed leading-edge extension at Wing Stations 57.00 to 141.10. The flap is attached to the 15-percent chord spar by five hinges which incorporate self-aligning bearings. The flap is of conventional aluminum rib, spar, and skin construction.

Trailing-Edge Flap. A partial-span plain-trailing-edge flap with a chord equal to 25 percent of the wing chord extends from the side of the fuselage outboard to Wing Station 84.50. The trailing-edge flap is a two-spar design with conventional ribs and a full-depth aluminum honeycomb trailing section.

Aileron. The aileron is located outboard of the trailing-edge flap and extends from Wing Stations 84.50 and 116.50, with the hinge line on the 70-percent-chord line. The aileron is a conventional two-spar-and-rib arrangement forward of the rear spar, and full-depth honeycomb from the rear spar to the trailing edge. All materials used in the aileron are aluminum alloy except the inboard steel hinge. The aileron has two hinge points and is actuated at the inboard hinge by a double-cylinder hydraulic actuator.

Speed Brakes. Two speed brakes (magnesium castings) are mounted in a 3-piece speed brake installation. The left and right hand speed brakes are separated by a fixed center panel. Each speed brake package is mounted on four brackets bolted to the wing box structure and is retained by pins for easy removal. The center fixed panel is bolted to the fuselage at the forward end with a shear attachment at the rear.

Leading-Edge Extension. The leading edge extension is an extension of the wing inboard of the leading edge flap. It is supported by the 15-percent chord spar and shear attachment at the outboard surface of the air inlet nacelle. It is fabricated of ribs and spars with a cavity which houses the leading edge flap actuation mechanism.

### Structural Design Criteria

The F-5E/F structural design criteria are based on the requirements of MIL-A-8860, MIL-A-8871 and AFSCM 80-1 (HIAD). Details regarding these criteria are found in NOR-69-35. The F-5E is a class $F_{II}$ fighter with 7.33g flight capability in the air-to-air configuration throughout the combat area of the flight envelope. The load factor capability for 50 percent fuel is presented in Figure 4-14. In the air-to-ground role, the aircraft has a 6.5g capability for configurations with underwing stores. The symmetrical load factors used for structural design are shown in Figure 4-15 for several loading conditions. The limit speed for airframe design considerations is a speed equivalent to a dynamic pressure of 1700 psf or Mach 2.0 whichever is less.

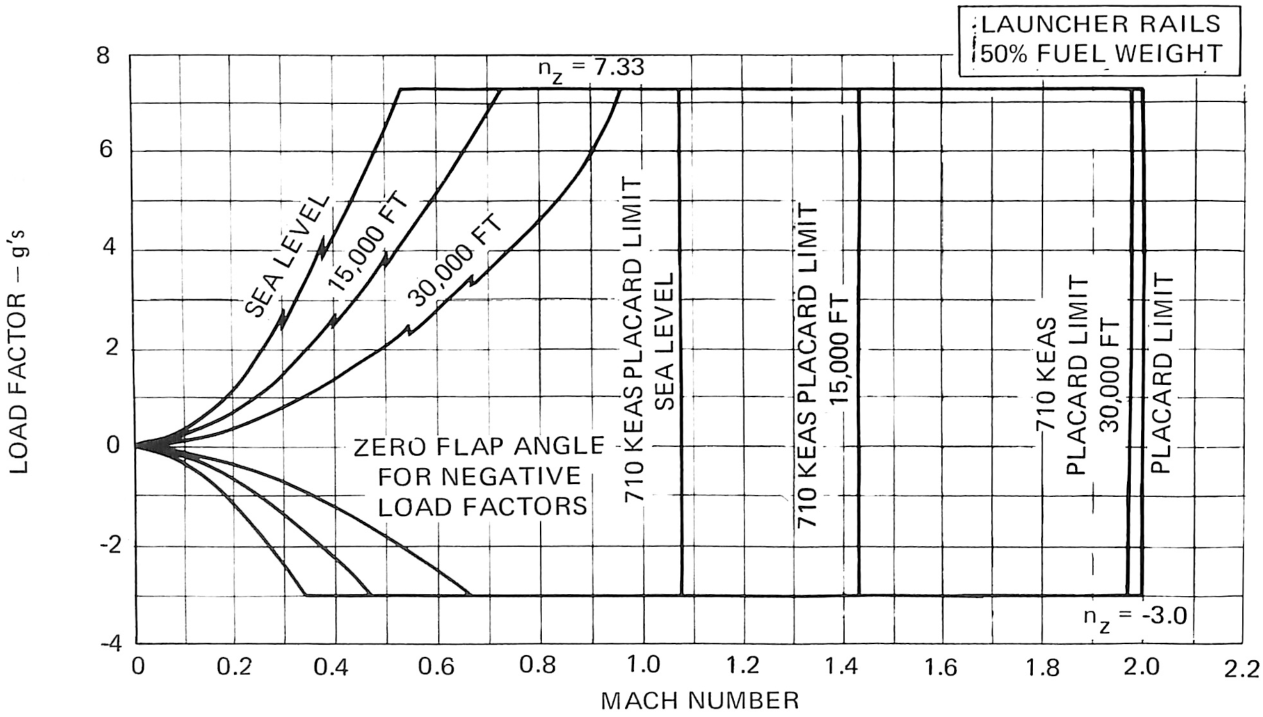

FIGURE 4-14. F-5E STRUCTURAL LOAD FACTOR DIAGRAM

The flutter characteristics of the F-5E and F-5F in the air-to-air role are unrestricted throughout the flight envelope. Flutter clearances for stores range from 520 KEAS or 0.85M* for heavy loads up to $V_{max}$ level flight for light store loadings.

The cockpit acoustic environment at normal cruise power and maximum continuous power are within the requirements of MIL-A-8806B at all octave band sound pressure spectra.

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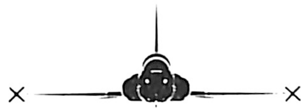
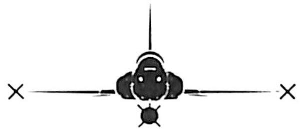
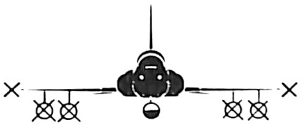
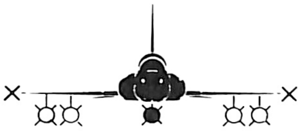
*Whichever is less. Refer to T.O. 1F-5E-1 for limits of specific configurations.

| CONFIGURATIONS (ALL WITH FULL AMMO) | | WEIGHT LB | DESIGN LOAD FACTOR $+n_z$ | $-n_z$ |
|---|---|---|---|---|
| BASIC MISSION  | 100% INT FUEL | 15,745 | 7.33$^{(1)}$ | -3.00 |
| | 50% INT FUEL | 13,565 | 7.33 | -3.00 |
| ALTERNATE I  | 100% INT FUEL | 17,860 | 5.00 | -2.00 |
| | 75% INT FUEL | 16,770 | 5.00 | -2.00 |
| | LESS ℄ STORE | 14,800 | SEE BASIC MISSION | |
| ALTERNATE II  | 100% INT/EXT FUEL | 21,682 | 4.00$^{(4)}$ | -2.00 |
| | LESS ℄ TANK | 19,696 | 6.50$^{(2)}$ | -2.00 |
| | 75% INT FUEL | 18,606 | 6.50$^{(2)}$ | -2.00 |
| | LESS INBD STORES | 16,946 | 6.50$^{(2)}$ | -2.00 |
| | LESS OUTBD STORES | 15,286 | SEE BASIC MISSION | |
| ALTERNATE III  | 100% INT FUEL | 21,818 | 5.00 | -2.00 |
| | 75% INT FUEL | 20,728 | 5.00 | -2.00 |
| | LESS ℄ STORE | 18,758 | 6.50$^{(2)}$ | -2.00 |
| | LESS INBD STORES | 16,022 | 6.50$^{(3)}$ | -2.00 |
| | LESS OUTBD STORES | 15,286 | SEE BASIC MISSION | |

EXTERNAL STORE LEGEND:

✕ AIM-9 MISSILE
⊖ 275-GAL FUEL TANK
● MK-84 BOMB
⊗ M117 BOMB (GROWTH)
○ BLU-27 (FINNED) BOMB

NOTES:

(1) LINEAR REDUCTION ABOVE 0.95M TO 6.5g AT 2.0M
(2) LINEAR REDUCTION ABOVE 0.85M TO 5.0g AT 1.0M ($V_L$)
(3) LINEAR REDUCTION ABOVE 0.85M TO 5.0g AT 1.4M ($V_L$)
(4) 275-GAL FUEL TANK LIMITATION

FIGURE 4-15. F-5E STRUCTURAL DESIGN CRITERIA (SEE REPORT NOR 69-35)

The current F-5E fatigue analysis and test program is based on an 85-percent air-to-air, 15-percent air-to-ground spectrum and a required airframe life of 4000 hours. Fatigue analysis and testing are based on combining typical mission profiles in these proportions with maneuver load factor occurrence data presented in the latest USAF fatigue Specification, MIL-A-008866A dated 31 March 1971. The successful completion of this program has established a 4000-hour airframe service life for this spectrum.

The F-5F fatigue program is based on results from theF-5E analysis and test program. Emphasis is placed on the structure unique to the two-place airplane and fatigue critical locations and areas that were disclosed in the F-5E program.

Specific detailed mission criteria defining the operational spectra are required from the user to make a more accurate estimate of the F-5E/F service life under his specific usage.

Airframe fatigue life is a function of actual usage. The USAF recognizes this and has authorized two incremental follow-on F-5E fatigue tests. The first incremental test spectrum, in combination with the current 85-percent air-to-air test spectrum, will simulate four lifetimes of usage by the 425th Fighter Weapons Training Squadron at Williams Air Force Base (WAFB). WAFB airplanes have VGH recorders installed and this test program is now in progress. The second incremental fatigue test spectrum, in combination with the two prior test programs, will simulate four lifetimes of usage by the 14th Flight Weapons Squadron at Nellis Air Force Base for the dissimilar airplane air combat maneuver training. Successful completion of these programs will establish the 4000-hour service life for these spectra.

It should be noted that all of the above spectra - the 85-percent air-to-air spectrum, the Williams spectrum, and the Nellis spectrum - are more severe than the spectrum experienced by F-5A/B aircraft in Vietnam, which was essentially a 100-percent air-to-ground activity. Northrop expects that the F-5E/F service life for a spectrum based on predominantly air-to-ground usage will be well in excess of 4000 hours.

Following completion of the testing to verify the 4000-hour service life in the WAFB training spectrum, the spectra of other users whose operational usage is predominantly air-to-ground can be compared to the WAFB training spectrum and the service life of their aircraft established. In most cases the spectra will be less severe than the WAFB training spectrum. This will result in the establishment of a service life in excess of 4000 hours for those users' aircraft. In the event a user desires to establish the aircraft service life based on his specific criteria, the user's spectrum must be determined either from analysis of his flight operations or from VGH recorder measurements.

When an aircraft approaches its established service life, it is USAF policy to conduct follow-on testing to verify the ability to extend the service life. In many cases this extension can be accomplished without further modification of the aircraft. It should be noted that the high-time aircraft will undoubtedly be those used for training at WAFB. Consequently, any follow-on testing for extension of service life would probably be completed prior to the time any other user's aircraft reach the service life limit.

## PROPULSION SYSTEM

### Engines

Propulsion power for the F-5E/F aircraft is supplied by two identical J85-GE-21 afterburning turbojet engines mounted one on each side of the keel in the aft section of the center fuselage. The engine is a member of the J85 family which has progressed from the -5, -13 through the -15. These engines presently power the T-38, F-5A/B, CF-5A/D and NF-5A/B aircraft.

Refinements in materials and engine technology during operational usage of the J85 family have brought about increased service life, reduced maintainability requirements, and substantially increased performance both in terms of total thrust and in higher thrust-to-weight ratio. With afterburner, the J85-GE-21 engine produces 5,000 pounds of sea level static thrust, which results in an engine thrust-to-weight ratio of approximately 7.5 based on a current dry engine weight of 665 pounds.* The afterburner can be modulated from minimum to maximum afterburning. The sea level static thrust for minimum afterburning is 3,900 pounds. The afterburner thrust is infinitely variable between the minimum and maximum thrust levels. The J85-GE-21 engine is presently one of the highest thrust-to-weight ratio turbojet engines in production and has a design goal of 2400-hour TBO (time before overhaul).

The -21 engine is shown in Figure 4-16 and the specifications in Table 4-1. The engine consists of a nine-stage titanium compressor rotor coupled directly to an improved-design two-stage turbine; a through-flow, annular-type combustion system; variable inlet guide vanes and three stages of variable stators; an integrated control system which automatically modulates thrust in response to a single input demand and an afterburner with a hydraulically controlled variable-area exhaust nozzle.

The engine-mounted equipment driven by the engine accessory gearbox consists of the main and afterburner fuel controls, a variable exhaust nozzle power unit, an overspeed governor, a tachometer generator, and a lubrication and scavenge pump. An auxiliary pad is also provided for driving an airframe-mounted accessory drive gearbox assembly.

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*Specification engine weight is 675 pounds.

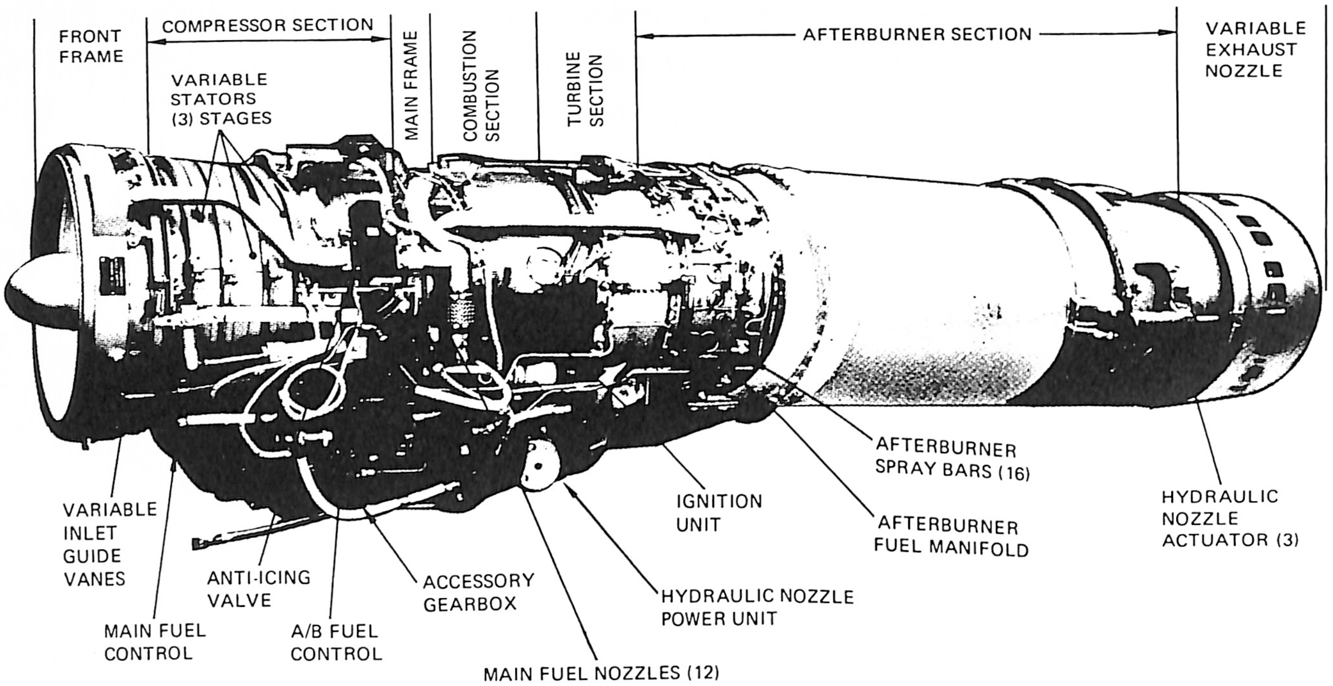
FRONT FRAME
COMPRESSOR SECTION
VARIABLE STATORS (3) STAGES
MAIN FRAME
COMBUSTION SECTION
TURBINE SECTION
AFTERBURNER SECTION
VARIABLE EXHAUST NOZZLE
AFTERBURNER SPRAY BARS (16)
HYDRAULIC NOZZLE ACTUATOR (3)
IGNITION UNIT
AFTERBURNER FUEL MANIFOLD
VARIABLE INLET GUIDE VANES
ANTI-ICING VALVE
ACCESSORY GEARBOX
HYDRAULIC NOZZLE POWER UNIT
MAIN FUEL CONTROL
A/B FUEL CONTROL
MAIN FUEL NOZZLES (12)

FIGURE 4-16. J85-GE-21 ENGINE

## TABLE 4-1. BASIC J85-GE-21 ENGINE SPECIFICATIONS

| SPECIFICATION | VALUE |
|---|---|
| WEIGHT (DRY) | 675 POUNDS |
| LENGTH (MAXIMUM HOT) | 117.4 INCHES |
| DIAMETER (MAXIMUM HOT) | 20.4 INCHES |
| COMPRESSOR STAGES | 9 |
| COMPRESSOR PRESSURE RATIO | 8.1 (100% RPM SEA LEVEL STATIC) |
| AIR FLOW | 51.9 LB/SEC |
| TURBINE STAGES | 2 |
| ENGINE MILITARY SPEED | 16,600 (100% RPM) |
| ENGINE IDLE SPEED | 8,300 (50% RPM) |
| FUEL | MIL-T-5624, GRADE JP-4, NATO F-40 |
| OIL | MIL-L-7808F OR MIL-L-7808G, NATO O-148 |

| SEA LEVEL STATIC RATING | RPM | GUARANTEED THRUST (POUNDS) | SPECIFIC FUEL CONSUMPTION (LB/HR/THRUST) |
|---|---|---|---|
| MAXIMUM WITH AFTERBURNER | 16,600 | 5,000 | 2.13 |
| MILITARY | 16,600 | 3,500 | 1.00 |
| NORMAL | --- | 3,280 | 0.99 |

The main fuel control is a hydromechanical unit which regulates fuel flow during steady state and transient operation within prescribed engine limitations. The control senses power control angle, engine RPM, compressor discharge pressure, and compressor inlet temperature to maintain scheduled engine speed for a specific power control setting at all altitudes and Mach numbers, and to position the compressor inlet variable geometry. The control automatically schedules engine speed during military power and afterburner operation as a function of compressor inlet temperature and compressor discharge pressure.

The afterburner fuel control is a hydromechanical unit which schedules fuel throughout the afterburner range. The control also schedules the position of the variable exhaust nozzle by supplying an input signal to the nozzle actuation system. The area of the exhaust nozzle is scheduled as a function of power control position and exhaust gas temperature.

Engine anti-icing is accomplished with compressor bleed air from the ninth-stage circulated through the inlet guide vanes, the dome assembly, and the front frame-mounted temperature sensor. A switch located on the cockpit right-hand vertical control panel (front cockpit only in the F-5F) provides control of the engine anti-ice system. The ENG ANTI-ICE ON light on the caution light panel (both cockpits in the F-5F) will illuminate when the engine anti-ice switch is turned on and remains lighted until the switch is turned off.

The primary engine fuel is MIL-J-5624 Grade JP-4 (NATO F-40). Airplane markings, weight, tests, and performance are based on the use of this fuel. Jet A-1 fuel with fuel system icing inhibiter (Jet A-1 W/FSII) can also be used. F-5E performance with both JP-4 fuel and Jet A-1 fuel is presented in Section 2. In an emergency, the engine and fuel system components operate satisfactorily and are compatible with JP-5 (NATO F-44) fuel.

Airframe-mounted accessories (generator, hydraulic pump, etc.) can be removed easily through access doors without removing or compromising the integrity of the engine. Likewise, engines can be removed without compromising the integrity of the hydraulic and electrical systems.

A removable aft section on the aircraft and various access panels on the fuselage aft section provide access to the more important engine components for normal servicing, control adjustment and accessory replacement. Replacement of major engine subsystem components requires engine removal.

After the aft fuselage section is removed, the afterburner assembly and its components can be removed and replaced. Each engine is demounted from the engine bay at three points: an engine main trunnion mount at each side of the afterburner diffuser section horizontal centerline, and an engine front mount at the top of the main frame. The engine can be rolled in or out of the fuselage on an overhead monorail with the aid of an engine removal adapter and trailer.

### Starting System

Engine starting is accomplished by air impingement on the second stage turbine. Air is supplied through a low-pressure distribution system from a ground service air-start cart such as the USAF MA-1A (or the equivalent) which can deliver up to 100 lb/minute of 43 psia air at 360°F. Air is introduced into a manually operated diverter valve which directs air to either engine's start impingement horn. A crossbleed start system is provided for starting the right-hand engine by utilizing compressor bleed air from the left-hand engine. The crossbleed start system provides scramble start capability, i.e., the left-hand engine is started using a start cart and the right-hand engine can then be started while taxiing. Engine start pushbuttons (one for each engine) are provided on the left vertical control panel (both cockpits in the F-5F). These switches are used for both ground start and air start operations. Power to the pushbutton switches is interlocked with the battery relay, to prevent engine starting with the battery switch in the off position. Actuation of the right engine start pushbutton switch when the aircraft is on the ground, with the left engine operating above 90 percent rpm, will operate the air crossbleed valve for crossbleed start. With external electrical power applied to the aircraft, ignition power is supplied to both engine start and ignition systems. Without external electrical power applied to the aircraft, 115-volt ac power for the left engine instruments and ignition for either engine is supplied by an inverter operated from the aircraft battery. Average engine start time is 20 seconds. In flight, the engine airstart capability is highly reliable up to an altitude of 30,000 feet. Inflight airstarts can also be initiated without using the start buttons by advancing the throttles into afterburner for "tiger" starts.

The F-5E/F has an 11-ampere-hour battery and is capable of unrestricted starting down to -40°F. Engine starts can be accomplished after limited soak periods at temperatures between -40°F and -65°F; however, for prolonged soak periods at these temperatures, standard arctic techniques of battery storage, per T.O. 8D2-3-1 and T.O. 00-60B-1, should be used.

### Engine Air Induction System

The air induction system has been designed for engine/airframe compatibility throughout the flight envelope of the aircraft, with special emphasis on the speed range and high attitude conditions expected to be encountered in a dogfight. The system consists of fixed geometry inlets which incorporate splitter plates to divert fuselage boundary layer air, internal ducting terminating at a short bellmouth duct attached to the compressor face, plenum, and axuiliary air inlet doors located adjacent to the bellmouth as shown in Figure 4-17. All propulsion system air, both primary engine and secondary cooling, is taken onboard through the main engine inlet, and the auxiliary air inlet doors which furnish additional air during ground operation and at low flight Mach numbers.

The inlets are D-shaped with the cowl swept back from the front edge of the splitter-plate (6-degree ramp) to prevent the intersection of the cowl and the splitter-plate-attached oblique shock at Mach numbers up to 1.6. This cowl sweep-back forms

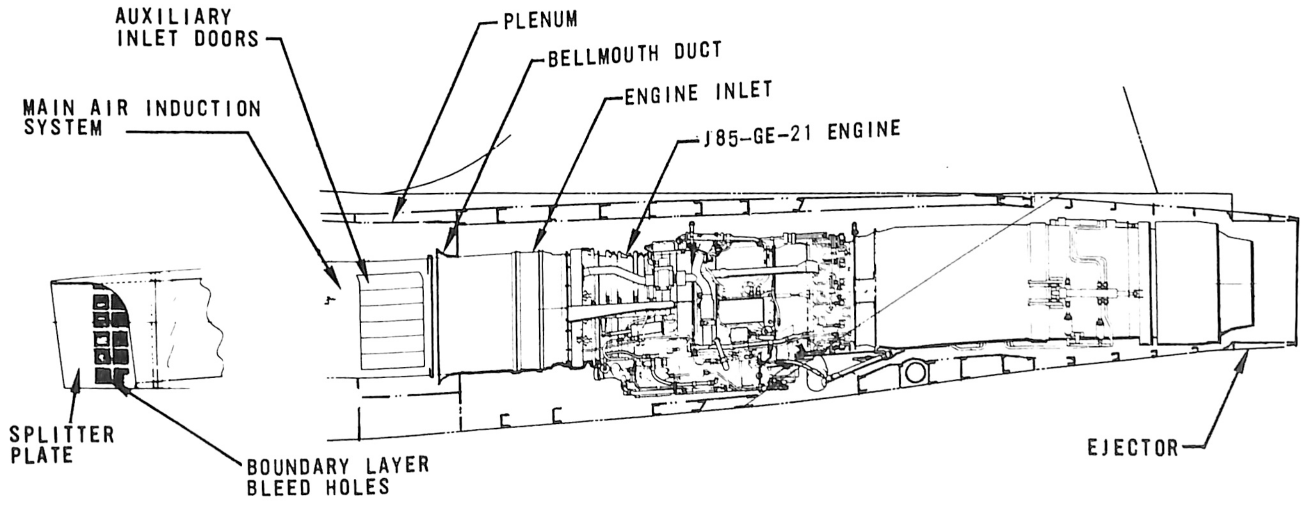

FIGURE 4-17. F-5E/F J85-GE-21 ENGINE INSTALLATION

natural side fairings at the top of the inlets and tends to maintain a two-dimensional flow pattern over the ramp and into the inlet during normal flight conditions. The bottom fairing is omitted to prevent flow separation at high angles of attack.

The inlet splitter plates are positioned off the fuselage to prevent fuselage boundary layer air from entering the inlet and to minimize interaction of the inlet shock wave and the fuselage boundary layer. The splitter plate and upper cowl incorporate boundary layer removal to prevent interaction between the inlet bow shock and splitter plate boundary layer. This boundary layer air flows into a plenum area behind the bleed plate and is ducted through check valves to the air-conditioning unit bay, then overboard through the bay louvered exits. The check valves preclude low energy air from going out the bleed plate into the inlet during low speed subsonic flight and ground operation.

Internally, the ducting is shaped to form a smooth transition from a D-shaped section at the inlet to a circular section at the engine compressor face. A small area-expansion ratio and large length-to-diameter ratio provide a reasonably long mixing section within the duct; this section effectively dampens flow irregularities existing at the inlet. A bellmouth is incorporated at the engine inlet transition to provide increased recovery and lower compressor face distortion by smoothly mixing duct airflow and supplementary airflow during ground operation and at low airspeeds. Internal duct boundary layer air is removed through a slot ahead of the bellmouth to a plenum which completely encircles the duct. This plenum feeds air to the engine bay and keel to cool the engine and structure.

Auxiliary air inlet doors shown in Figure 4-18 open into the plenum during takeoff and low-speed flight to improve compressor face pressure recovery and to decrease distortion. Each auxiliary air inlet door consists of a set of six pivot-mounted louvers in removable panels, on each side of the fuselage.

The louvers are mechanically interconnected with links and cranks to rotate in unison to open or seal the door opening as required. A driver louver is linked by a pushrod to a 115 vac, 320-480 Hz rotary actuator. The doors are automatically controlled by signals from the central air data computer (CADC). An indicator located in the right-hand instrument panel (both cockpits in the F-5F) denotes three door positions: full open, full closed or intermediate. Both doors are maintained open at airspeeds below 0.35 to 0.40 Mach number.

The air induction system is designed to minimize foreign object ingestion. The inlets are located forward of and above the wing. The low energy vortex generated at

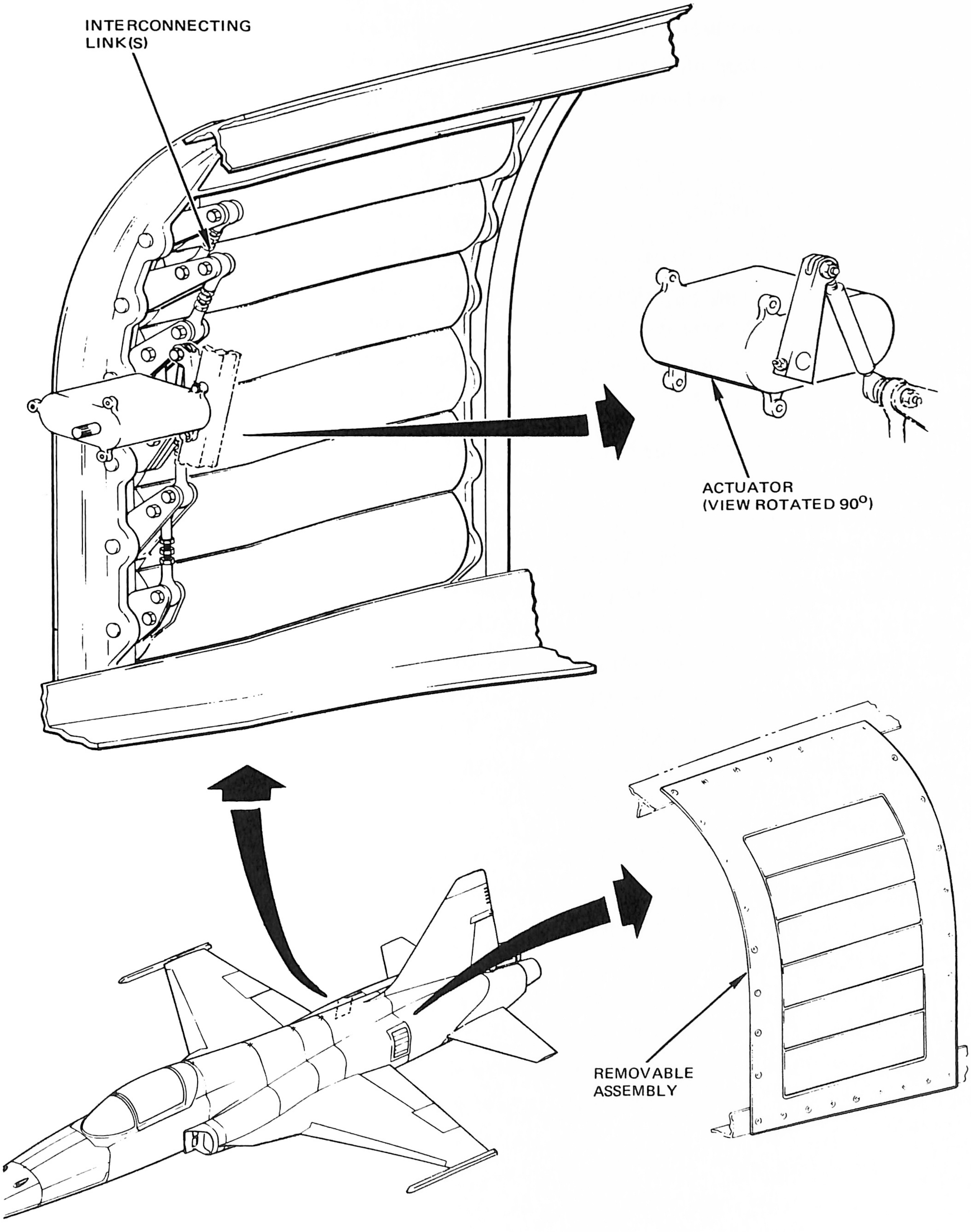
INTERCONNECTING LINK(S)
ACTUATOR (VIEW ROTATED 90°)
REMOVABLE ASSEMBLY

FIGURE 4-18. AUXILIARY AIR INLET DOOR SYSTEM

the inlet is too weak to pick up any object off the runway during ground operation. In addition, the gun installation has screens on the link boxes and gun bay purge door outlets to prevent escape of objects that might enter the engine inlets during flight. The auxiliary air inlets are located above the wing trailing edge and are protected by the wing.

### Propulsion System Cooling

The aft fuselage is composed of three isolated compartments — the right and left engine bays and the keel compartment. The engine bays are the firewall shrouded compartments containing the engines. The keel compartment is that area between the two shrouded engine bays and between the engine bay shrouds and the outer skin. The keel area resembles a figure eight in cross section.

Propulsion system cooling provisions are depicted in Figure 4-19. Cooling air for the engine bays and the keel compartment is obtained from peripheral bleed slots in the induction system plenum. The airframe-mounted gearbox is cooled by air impingement from those slots directly forward of it. The generator is also cooler internally by air ducted from the plenum to a self-contained blower. Generator cooling exhaust air then mixes with engine bay cooling air which flows over the compressor section and the engine combustion section. At this point, the flow divides to pass over and under the turbine section. The keel compartment cooling air is supplied by the plenum chamber and flows aft through holes in the fuselage frames. This air exhausts through holes in the base frame of the aircraft thus reducing the aerodynamic base drag.

During ground operation, the ejector draws cooling air through the engine bay, getting its supply from the plenum chamber, which also supplies a portion of the engine air demand. The plenum in turn receives its air from the auxiliary inlet doors and a small portion from the keel compartment. The keel compartment air enters through the holes in the base frame and flows forward. The airframe-mounted gearbox and generator are cooled in the same manner as in flight, with the ejector inducing sufficient cooling flow to maintain all components within their respective temperature limits without the use of ground support equipment. The flight speed at which the keel cooling airflow changes from reverse flow to normal flow is a transient condition which occurs during takeoff and landing.

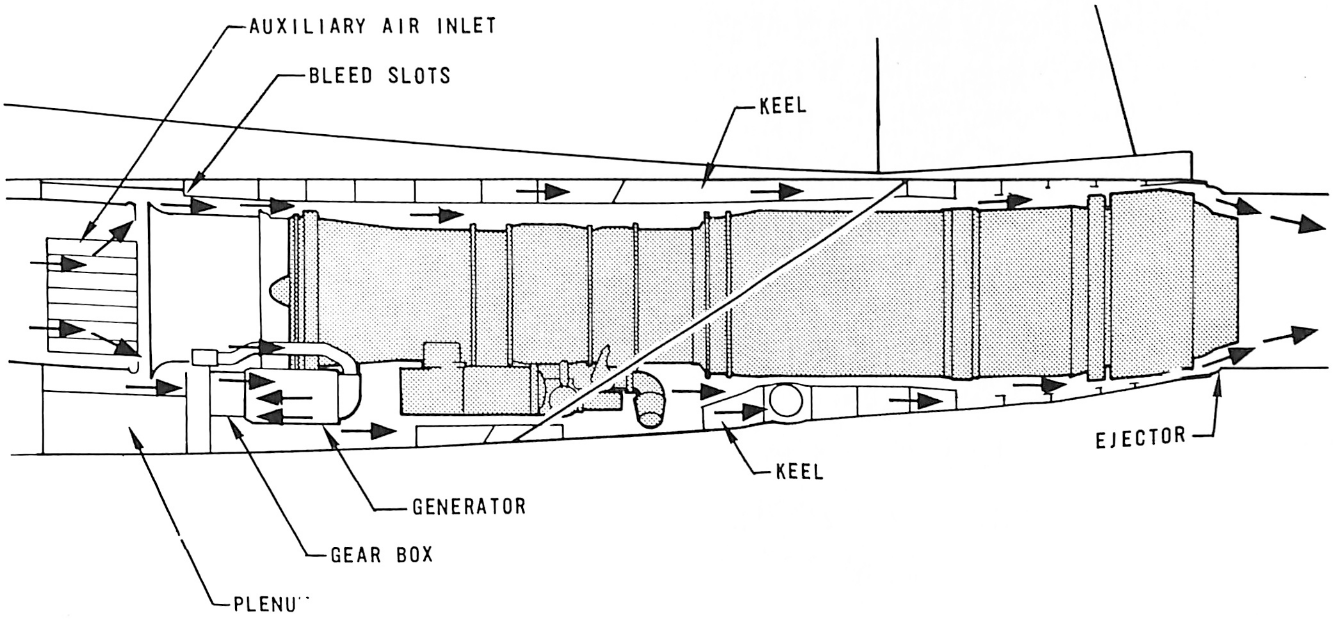

FIGURE 4-19. PROPULSION SYSTEM COOLING

## Fire Protection

Each engine bay is isolated from the rest of the aircraft by a titanium and stainless steel firewall. The firewall extends from the forward end of the air inlet plenum to the ejector in each engine bay. The unidirectional cooling airflow in the engine bay shown in Figure 4-19 isolates any fire from propagating forward or to the opposite engine. Drain outlets are located so that fluids will not impinge on the aircraft. All fluid lines and fittings within the engine bay are of fireproof construction.

An independent fire detection circuit is provided in each engine compartment. I is a continuous loop, resistance type system which meets the requirements of MIL-D-7872C. When a fire or overheat condition is detected in the engine bay, a FIRE warning light illuminates on the instrument panel (both cockpits in the F-5F). The system senses continuously and the warning light remains illuminated throughout duration of the fire. When the fire goes out, the warning light goes out. If the fire should re-ignite, the warning light will again illuminate. The system can function with an open loop and precludes giving a false warning in the event of an accidentally grounded circuit. In addition to the fire warning light, the system consists of a temperature sensi cable and a fire detection control unit.

### Power Control

The F-5E power control system consists of dual power control levers mounted in a cockpit quadrant as shown in Figure 4-20 and a closed-cable system to a quadrant adjacent to each engine. The cockpit power control quadrant utilizes adjustable cams with a positive stop at off, idle, and maximum positions; and a detent at military power position. The power control system allows modulation in the afterburner range. Finger lifts are used to pass the idle stop for stop-cocking (shutting off) each engine.

The power control quadrant also incorporates a flap lever, maneuver flap thumb switch, speed brake switch, missile uncage switch, sight caging switch and a microphone switch. These are described under the respective systems.

Pushrods and linkage connect the aft cable quadrant to the main fuel control on the engine. A single-point control disconnect is provided on the vertical pushrod.

The F-5F power control system is similar to the F-5E and consists of dual power control levers mounted on a cockpit quadrant (Figure 4-21) in both cockpits. Finger lifts which are used to pass the idle stop for stop-cocking (shutting off) each engine are provided in the front cockpit only (identical to the F-5B). The power control quadrant also incorporates a flap lever, maneuver flap thumb switch, speed brake switch, missile uncage switch (front cockpit only), sight caging switch (front cockpit only), and a microphone switch.

## FUEL SYSTEM

The F-5E/F fuel system consists of an independent fuselage supply system with tank-mounted booster pump for each engine, a fuel vent system, a pressure-refueling system, a cockpit switch-controlled crossfeed valve, and an external supply system. The capacity of the F-5E internal fuel cells is 677 gallons usable (4400 lb)* and the F-5F is 675.5 gallons usable (4390 lb).* The right fuel system has a greater capacity than the left system, therefore fuel balancing is required on each flight. A semiautomatic fuel balancing system is provided as described later in this section. The internal fuel cells and the external pylon tanks are shown in Figure 4-22. No fuel is carried in the wing.

### Internal Fuel System

Internal fuselage fuel is carried in three rubber impregnated bladder-type nylon fabric cells as shown in Figure 4-22 including explosion-suppressant reticulated foam. The left-hand engine fuel is supplied from the forward cell, and the center and aft cells supply fuel to the right-hand engine. The fuel cells are located with a minimum

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*Assuming JP-4 fuel with a density of 6.5 lb/gal.

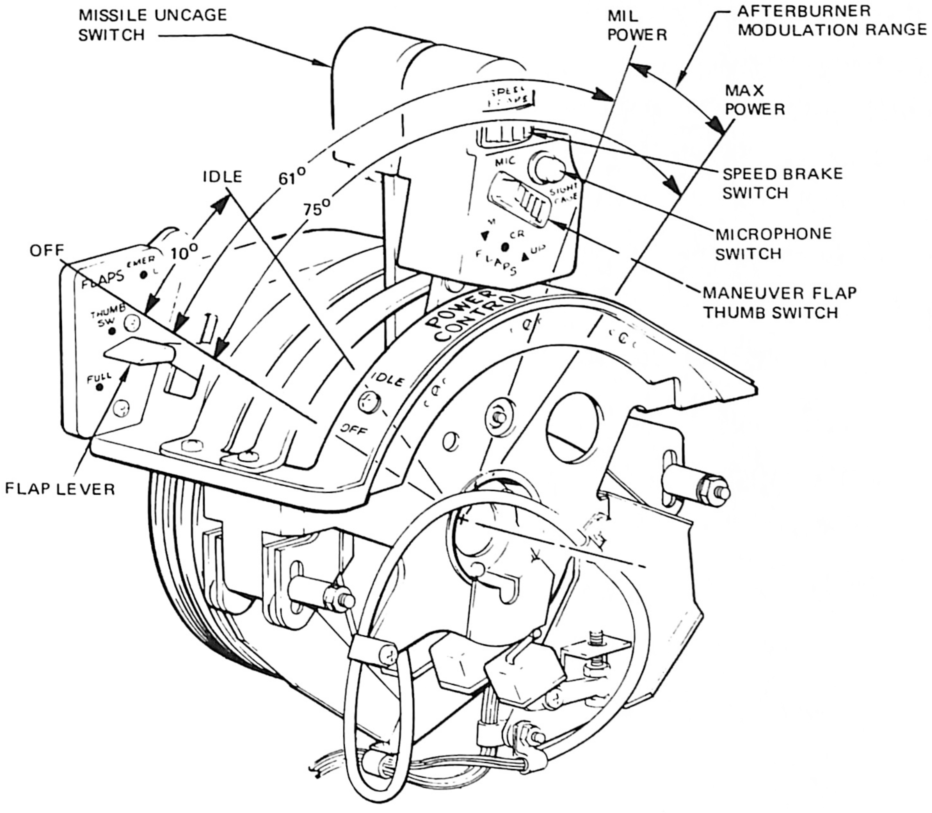

MISSILE UNCAGE SWITCH
MIL POWER
AFTERBURNER MODULATION RANGE
MAX POWER
IDLE
61°
75°
SPEED BRAKE SWITCH
OFF
10°
MICROPHONE SWITCH
MANEUVER FLAP THUMB SWITCH
FLAPS
EMER
THUMB SW
FULL
MIC
POWER CONTROL
IDLE
OFF
FLAP LEVER

FIGURE 4-20. F-5E POWER CONTROL QUADRANT

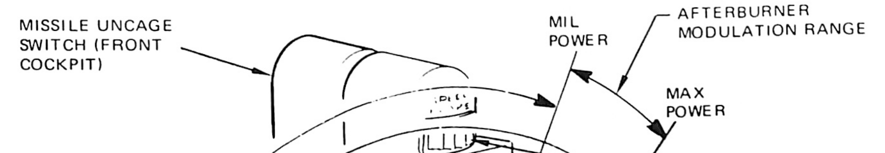

MISSILE UNCAGE SWITCH (FRONT COCKPIT)
MIL POWER
AFTERBURNER MODULATION RANGE
MAX POWER
IDLE
61°
75°
SPEED BRAKE SWITCH
OFF
10°
MICROPHONE SWITCH
MANEUVER FLAP THUMB SWITCH (FRONT COCKPIT)
FLAPS
EMER
THUMB SW
FULL
POWER CONTROL
IDLE
OFF
FLAP LEVER
SPEED BRAKE
MIC
SIGHT CAGE
CR
FLAPS
UP
TR
MANEUVER FLAP THUMB SWITCH (REAR COCKPIT)
TRANSFER POSITION

FIGURE 4-21. F-5F POWER CONTROL QUADRANT

of four inches of structure between the cells and the aircraft lower moldline to provide maximum protection against damage to the fuel tanks in the event of an emergency wheels-up landing.

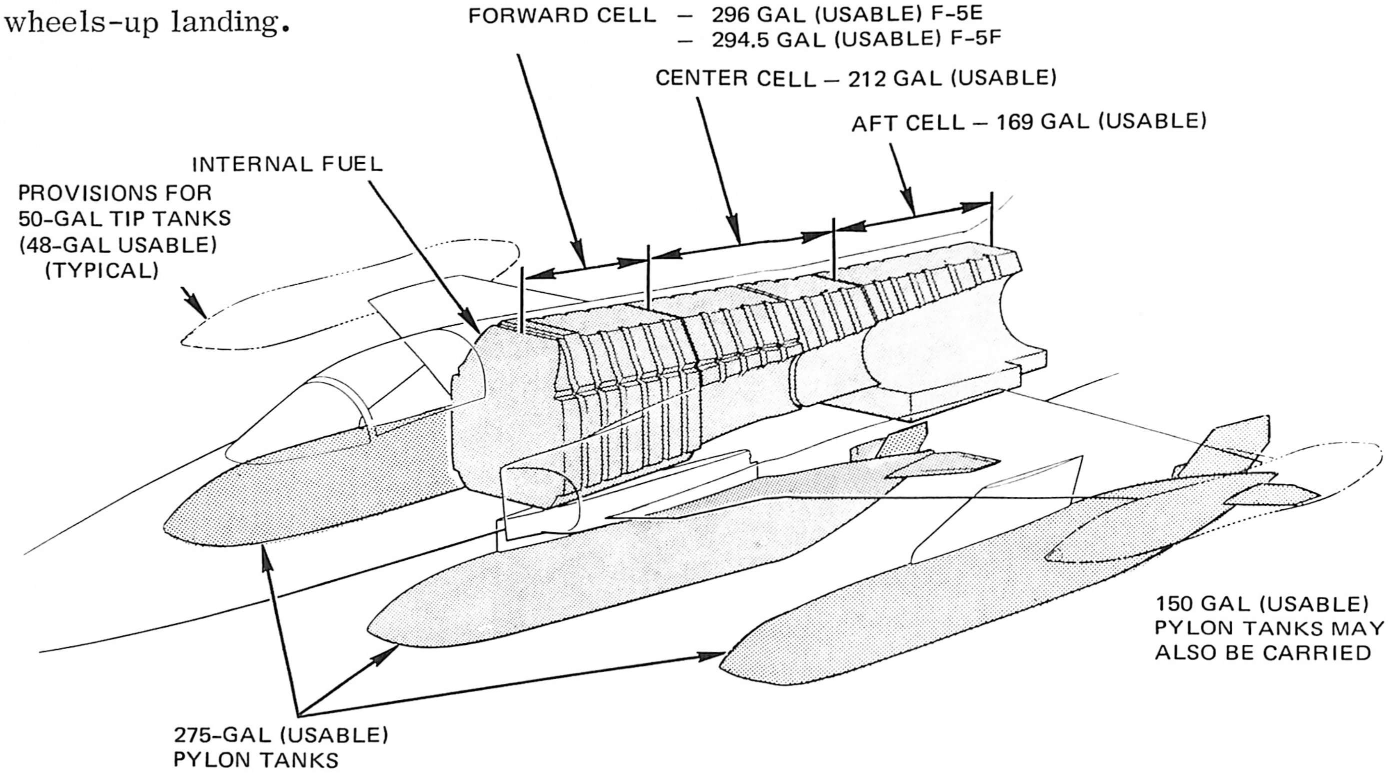

FORWARD CELL – 296 GAL (USABLE) F-5E
– 294.5 GAL (USABLE) F-5F
CENTER CELL – 212 GAL (USABLE)
AFT CELL – 169 GAL (USABLE)
INTERNAL FUEL
PROVISIONS FOR 50-GAL TIP TANKS (48-GAL USABLE) (TYPICAL)
150 GAL (USABLE) PYLON TANKS MAY ALSO BE CARRIED
275-GAL (USABLE) PYLON TANKS

FIGURE 4-22. F-5E/F FUEL TANKS

The internal fuel system, Figure 4-23, incorporates a common open type vent which is routed through a manifold from the fuselage fuel cells to the vent outlet at the trailing edge of the vertical stabilizer. A climb check valve in the left-hand system vent (forward cell) functions to preclude fuel transfer to the right-hand system (center and aft cells).

Fuel is pumped to each engine by AC-powered double-ended boost pumps located in each fuel system. A fuel booster pump low-pressure caution light (in both cockpits in the F-5F) is also provided for each system. In the event of a single booster pump failure, the remaining pump will provide fuel feed requirements to both engines through the crossfeed system under all normal flight conditions. If both fuel pumps fail, sufficient fuel will flow by gravity to maintain maximum afterburner power from sea level to 6,000 feet and military power to 25,000 feet. Each double-ended boost pump is located in a small inverted-flight fuel compartment within the fuel cell to assure continuous fuel supply to the engines throughout all aerobatic maneuvers and for 10 to 60 seconds of flight at load factors of less than one g or negative load factors. A DC motor-driven shutoff valve is employed in each system and is controlled by the power control lever position. The valve is open when the respective power lever is at IDLE or above. It is closed when the power control lever is OFF. Fuel shutoff switches are provided in the cockpit (both cockpits in the F-5F) to independently shut off fuel flow to each

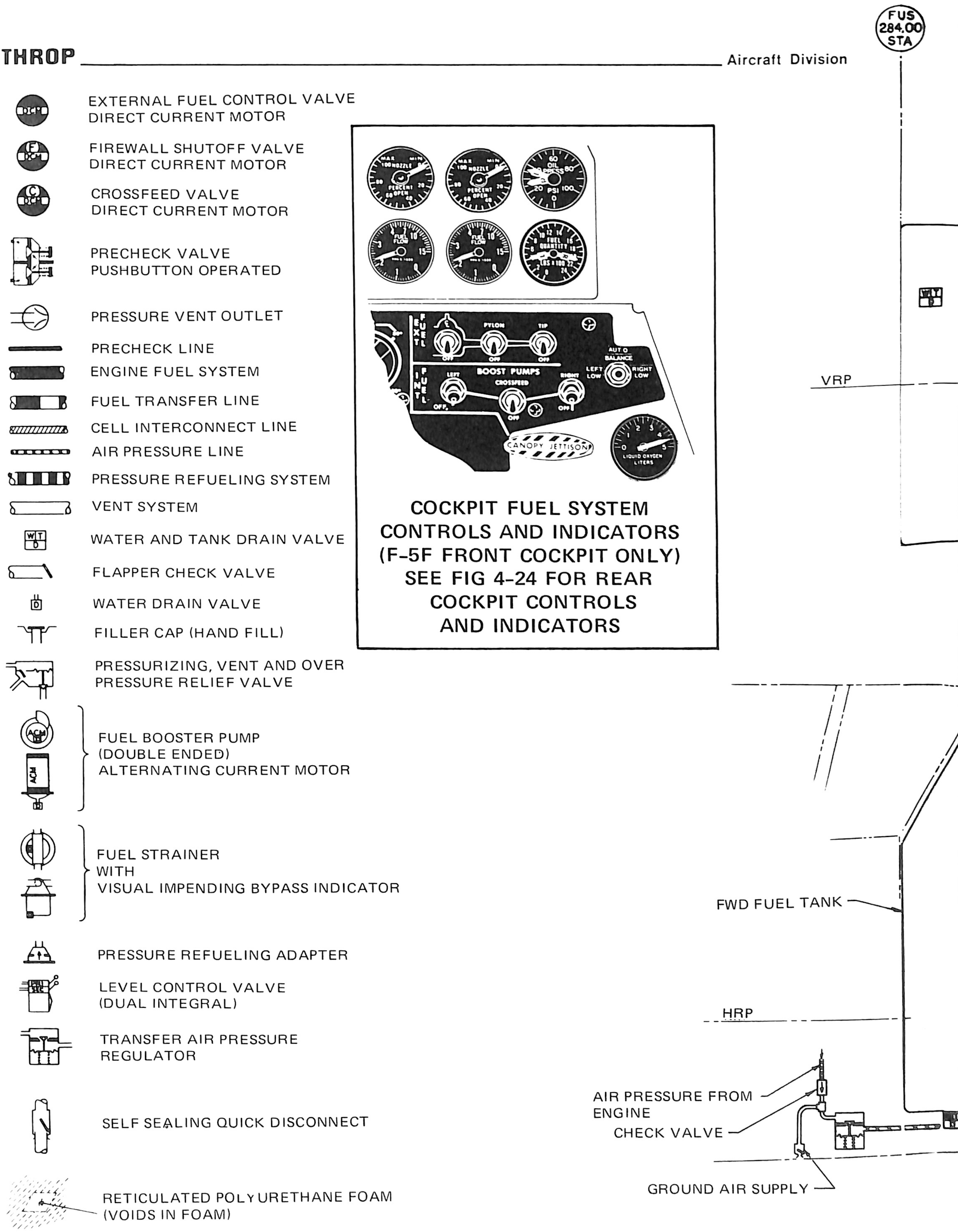
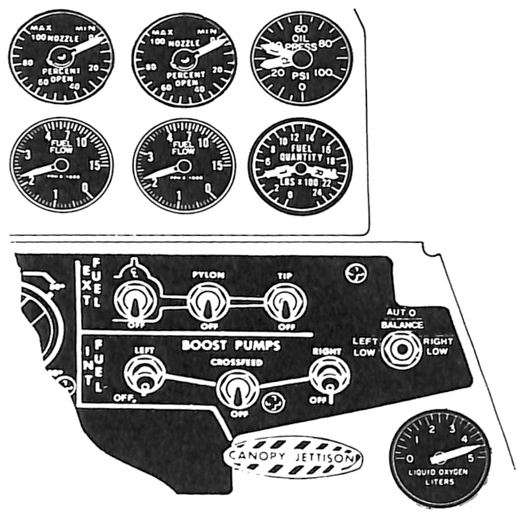
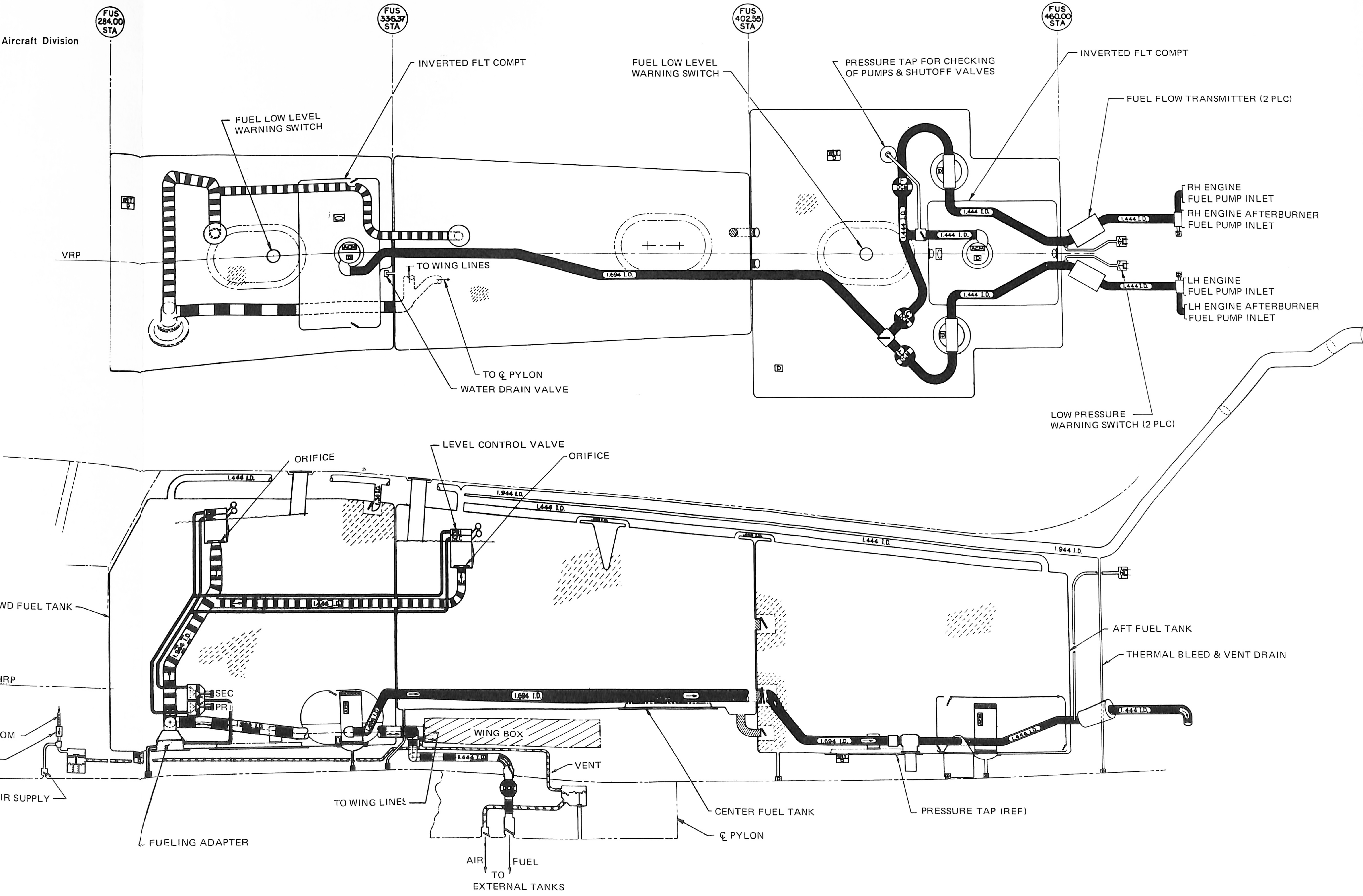

FUS 284.00 STA
EXTERNAL FUEL CONTROL VALVE DIRECT CURRENT MOTOR
FIREWALL SHUTOFF VALVE DIRECT CURRENT MOTOR
CROSSFEED VALVE DIRECT CURRENT MOTOR
PRECHECK VALVE PUSHBUTTON OPERATED
PRESSURE VENT OUTLET
PRECHECK LINE
ENGINE FUEL SYSTEM
FUEL TRANSFER LINE
CELL INTERCONNECT LINE
AIR PRESSURE LINE
PRESSURE REFUELING SYSTEM
VENT SYSTEM
WATER AND TANK DRAIN VALVE
FLAPPER CHECK VALVE
WATER DRAIN VALVE
FILLER CAP (HAND FILL)
PRESSURIZING, VENT AND OVER PRESSURE RELIEF VALVE
FUEL BOOSTER PUMP (DOUBLE ENDED) ALTERNATING CURRENT MOTOR
FUEL STRAINER WITH VISUAL IMPENDING BYPASS INDICATOR
PRESSURE REFUELING ADAPTER
LEVEL CONTROL VALVE (DUAL INTEGRAL)
TRANSFER AIR PRESSURE REGULATOR
SELF SEALING QUICK DISCONNECT
RETICULATED POLYURETHANE FOAM (VOIDS IN FOAM)
COCKPIT FUEL SYSTEM CONTROLS AND INDICATORS (F-5F FRONT COCKPIT ONLY) SEE FIG 4-24 FOR REAR COCKPIT CONTROLS AND INDICATORS
NOZZLE PERCENT OPEN
OIL PRESS PSI
FUEL FLOW
FUEL QUANTITY LBS x 100
EXT FUEL
PYLON
TIP
OFF
AUTO BALANCE
LEFT LOW
RIGHT LOW
INT FUEL
BOOST PUMPS
LEFT
CROSSFEED
RIGHT
CANOPY JETTISON
LIQUID OXYGEN LITERS
VRP
FWD FUEL TANK
HRP
AIR PRESSURE FROM ENGINE
CHECK VALVE
GROUND AIR SUPPLY

FIGURE 4-23. F-5E/F FUEL SYSTEM DIAGRAM

L VALVE
E
E
STEM
VALVE
OVER
MOTOR
S INDICATOR
APTER
CONNECT
HANE FOAM


MAX
MIN
100 NOZZLE
PERCENT OPEN
OIL PRESS
PSI
FUEL FLOW
FUEL QUANTITY
LBS x 100
EXT FUEL
PYLON
TIP
OFF
INT FUEL
BOOST PUMPS
LEFT
CROSSFEED
RIGHT
AUTO BALANCE
LEFT LOW
RIGHT LOW
CANOPY JETTISON
LIQUID OXYGEN LITERS

COCKPIT FUEL SYSTEM CONTROLS AND INDICATORS (F-5F FRONT COCKPIT ONLY) SEE FIG 4-24 FOR REAR COCKPIT CONTROLS AND INDICATORS


FUS 284.00 STA
FUS 336.37 STA
FUS 402.55 STA
FUS 460.00 STA
INVERTED FLT COMPT
FUEL LOW LEVEL WARNING SWITCH
FUEL LOW LEVEL WARNING SWITCH
PRESSURE TAP FOR CHECKING OF PUMPS & SHUTOFF VALVES
INVERTED FLT COMPT
FUEL FLOW TRANSMITTER (2 PLC)
RH ENGINE FUEL PUMP INLET
RH ENGINE AFTERBURNER FUEL PUMP INLET
LH ENGINE FUEL PUMP INLET
LH ENGINE AFTERBURNER FUEL PUMP INLET
VRP
TO WING LINES
1.694 I.D.
1.444 I.D.
TO ℄ PYLON
WATER DRAIN VALVE
LOW PRESSURE WARNING SWITCH (2 PLC)
ORIFICE
LEVEL CONTROL VALVE
ORIFICE
1.944 I.D.
FWD FUEL TANK
HRP
SEC
PRI
AIR PRESSURE FROM ENGINE
CHECK VALVE
GROUND AIR SUPPLY
WING BOX
VENT
TO WING LINES
FUELING ADAPTER
AIR
FUEL
TO EXTERNAL TANKS
CENTER FUEL TANK
℄ PYLON
PRESSURE TAP (REF)
AFT FUEL TANK
THERMAL BLEED & VENT DRAIN

3. F-5E/F FUEL SYSTEM DIAGRAM

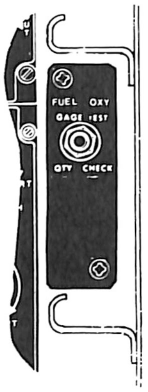
engine regardless of the power control position. A direct-current-operated crossfeed valve, controlled by a switch in the cockpit (front cockpit only in the F-5F) and located upstream of the firewall shutoff valves, permits fuel to be supplied from either or both cell systems to one or both engines. The crossfeed operation supplies fuel to both operating engines with one boost pump and is used to balance the quantity of fuel in each system.

A semiautomatic fuel balancing system is provided for the F-5E/F airplane. The balancing cycle is initiated by the pilot actuating an auto-balance selector switch (in front cockpit only in the F-5F) to either the LEFT LOW or RIGHT LOW position. The auto-balance switch actuation will be indicated in the rear cockpit of the F-5F by illumination of the CROSSFEED ON and corresponding LEFT BOOST OFF or RIGHT BOOST OFF indicator lights. The switch will remain in that position until the systems are balanced (within 50 to 125 pounds), then automatically return to its center position.

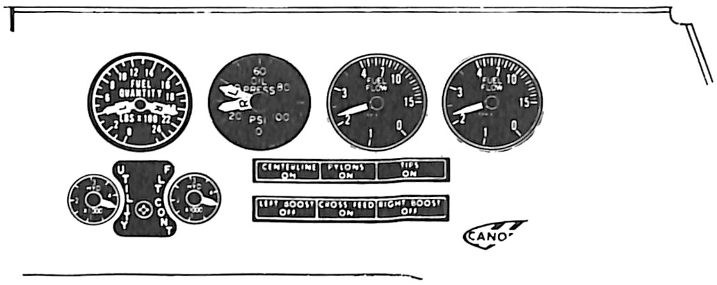
The pilot in the rear cockpit in the F-5F has no control over the fuel system except through the power control levers. However, he is able to monitor the management of the fuel system through indicator lights on the right vertical control panel. Yellow lights indicate left and right boost pumps off and crossfeed on. See Figure 4-24 for F-5F cockpit fuel system controls and indicators.

Both internal systems are equipped with a capacitance-type fuel gauging system which records fuel quantity directly on a dual-pointer indicator in the cockpit (both cockpits in the F-5F). A test switch is provided in the cockpit (front cockpit only in the F-5F) to check the fuel quantity and indicator operation. A FUEL LOW caution light (both cockpits in the F-5F) activated by the respective low level float switch comes on when the fuel quantity of either system reaches 380 pounds or less. The caution light is activated through a 10-second delay relay to minimize light activation during fuel slosh conditions.

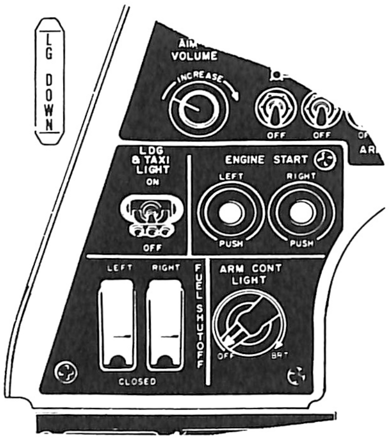
A single-point pressure refueling system is provided to fill both internal and external fuel tanks automatically. Total time to fuel internal and three external 275-gallon tanks is seven minutes. The refueling receptacle is located for maximum accessibility, safety, and minimum interference with maintenance and loading operations. During single-point fueling, fuel level control valves in each internal tank provide the fuel shutoff function when the tanks reach full capacity. Ground precheck of these valves is conducted during the refueling process. The precheck and the pressure refueling operation can be accomplished without the use of electrical power. An open


FUEL OXY
GAGE TEST
QTY CHECK

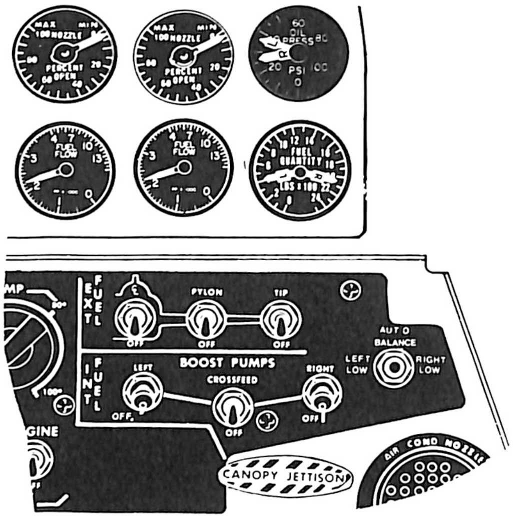
FUEL GAGE TEST AND
QUANTITY CHECK
CONTROL
FRONT COCKPIT ONLY


FUEL QUANTITY
LBS x 100
OIL PRESS
PSI
FUEL FLOW
CENTERLINE ON
PYLONS ON
TIPS ON
LEFT BOOST OFF
CROSS FEED ON
RIGHT BOOST OFF
CANOPY

REAR COCKPIT
INDICATORS


LG DOWN
AIR VOLUME
INCREASE
OFF
OFF
LDG & TAXI LIGHT
ON
OFF
ENGINE START
LEFT
RIGHT
PUSH
PUSH
LEFT
RIGHT
FUEL SHUTOFF
CLOSED
ARM CONT LIGHT
OFF
BRT

FUEL SHUTOFF CONTROL
BOTH COCKPITS


MAX MIN
NOZZLE
PERCENT OPEN
OIL PRESS
PSI
FUEL FLOW
FUEL QUANTITY
LBS x 100
EXT FUEL
PYLON
TIP
OFF
OFF
OFF
INT FUEL
BOOST PUMPS
LEFT
CROSSFEED
RIGHT
OFF
OFF
OFF
AUTO BALANCE
LEFT LOW
RIGHT LOW
CANOPY JETTISON
AIR COND NOZZLE

FRONT COCKPIT
CONTROLS AND INDICATORS

FIGURE 4-24. F-5F COCKPIT FUEL SYSTEM CONTROLS AND INDICATORS

vent system prevents damage to the tanks from overpressurization if the shutoff valves should fail. An alternate gravity filler cap is provided for each system. A description of the air refueling option is presented in Appendix A.

### External Fuel System

The F-5E/F is delivered with one jettisonable 275-gallon centerline external fuel tank. Complete provisions for carrying jettisonable 275-gallon external tanks on the inboard pylons are included. 150-gallon external tanks can also be accommodated on the centerline and inboard pylons. The 275-gallon wing pylon tanks and the 150-gallon centerline and wing pylon tanks are available as optional equipment and are described further in Appendix A. Complete provisions are also included to permit use of two removable but nonjettisonable 50-gallon wingtip tanks. However, tip tanks are not currently available as a developed option.

The external fuel system is connected to the internal system at the single-point fueling manifold, which permits single-point fueling of both internal and external systems, and prevents the internal tanks from overfilling during transfer. A level-control valve located in the external tank(s) shuts off fuel when the tank becomes filled during single-point fueling.

External tank fuel is transferred to the internal tanks by a tank pressurization system described on the following page. Fuel usage from the external tanks is selected by positioning the appropriate cockpit switch ℄, PYLON, or TIP as shown in Figure 4-23 (Front cockpit only in F-5F, Figure 4-24). The switches operate fuel shutoff valves in the respective pylons. The external tanks incorporate float-operated valves which control the fuel fill level and which stop the flow of pressurized air into the transfer system when the tanks are emptied. Float-operated switches in each tank power an EXT TANKS EMPTY light on the caution light panel when fuel transfer from the selected external system is completed. Each tank/pylon interface and each pylon/aircraft interface incorporates a self-sealing quick-disconnect fuel coupling which closes when the tank is jettisoned or when the pylon is jettisoned. (Tip tanks cannot be jettisoned.)

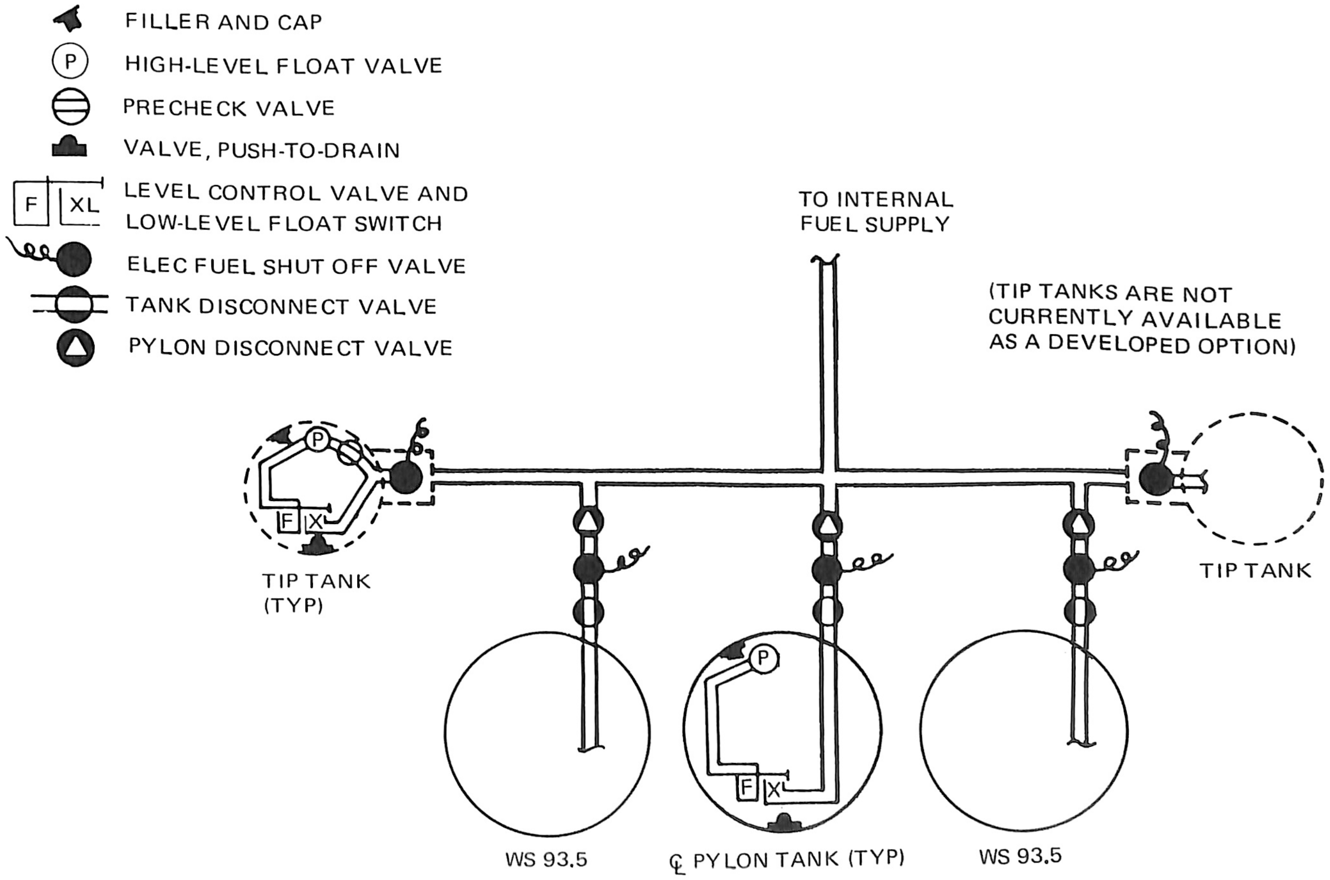

FILLER AND CAP
P HIGH-LEVEL FLOAT VALVE
PRECHECK VALVE
VALVE, PUSH-TO-DRAIN
F XL LEVEL CONTROL VALVE AND LOW-LEVEL FLOAT SWITCH
ELEC FUEL SHUT OFF VALVE
TANK DISCONNECT VALVE
PYLON DISCONNECT VALVE
TO INTERNAL FUEL SUPPLY
(TIP TANKS ARE NOT CURRENTLY AVAILABLE AS A DEVELOPED OPTION)
P
F X
TIP TANK (TYP)
TIP TANK
P
F X
WS 93.5
℄ PYLON TANK (TYP)
WS 93.5

FIGURE 4-25. F-5E/F FUEL TRANSFER SYSTEM

### Tank Pressurization System

Engine bleed air is used to pressurize the external tank(s) for fuel transfer. A pressure regulator regulates high-pressure bleed air to the lower pressure used for fuel transfer. Disconnect shutoffs prevent air loss at the pylons when the tanks are dropped. A pressurizing and vent valve vents the tanks during fueling and climbs.

### Fuel Flow Measurement

A total fuel flow indicating system is installed for each engine (both cockpits in F-5F). The system is calibrated to indicate fuel flow in pounds-per-hour (PPH) over a range of 0 to 15,000 PPH. The system consists of a transmitter and an indicator. The transmitter is located on the airframe and senses total fuel flow; that is, main engine flow and afterburner flow. The indicator is of the conventional single-pointer type as shown in Figure 4-26. The scale is expanded in the 0-4000 PPH range to afford accurate reading in the start-through-cruise fuel consumption range and compressed in the high-power-setting or afterburner range. The indicator is integrally lighted.

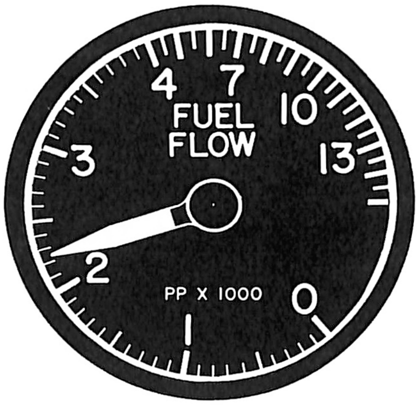


FIGURE 4-26. FUEL FLOW INDICATOR

## HYDRAULIC SYSTEM

Hydraulic power for the F-5E/F is provided by two completely independent systems, the flight control hydraulic system and the utility hydraulic system. Both systems have a nominal operating pressure of 3000 psi and utilize MIL-H-5606 hydraulic oil. The flight control hydraulic system provides power solely for the operation of the primary flight control surfaces. The utility hydraulic system, in addition to providing power to the primary flight control surfaces (the primary flight controls are powered by both hydraulic systems), also provides operating power for the main landing gear, two-position nose gear, landing-gear doors, speed brakes, wheel brakes, nosewheel steering, gun bay purge doors, gun-gas deflectors, and stability augmentation subsystems. The flight control hydraulic system is powered by a variable-delivery hydraulic pump mounted on the accessory drive gearbox assembly that is driven by the right-hand engine. The utility hydraulic system is powered by an identical variable-delivery hydraulic pump mounted on the accessory drive gearbox assembly and driven by the left-hand engine. Each system is completely independent, having separate pump, reservoir, filters, valving, and transmission lines. A diagram of the F-5E hydraulic systems is shown in Figure 4-27. The F-5F system is the same except for duplicate flight controls in the rear cockpit.

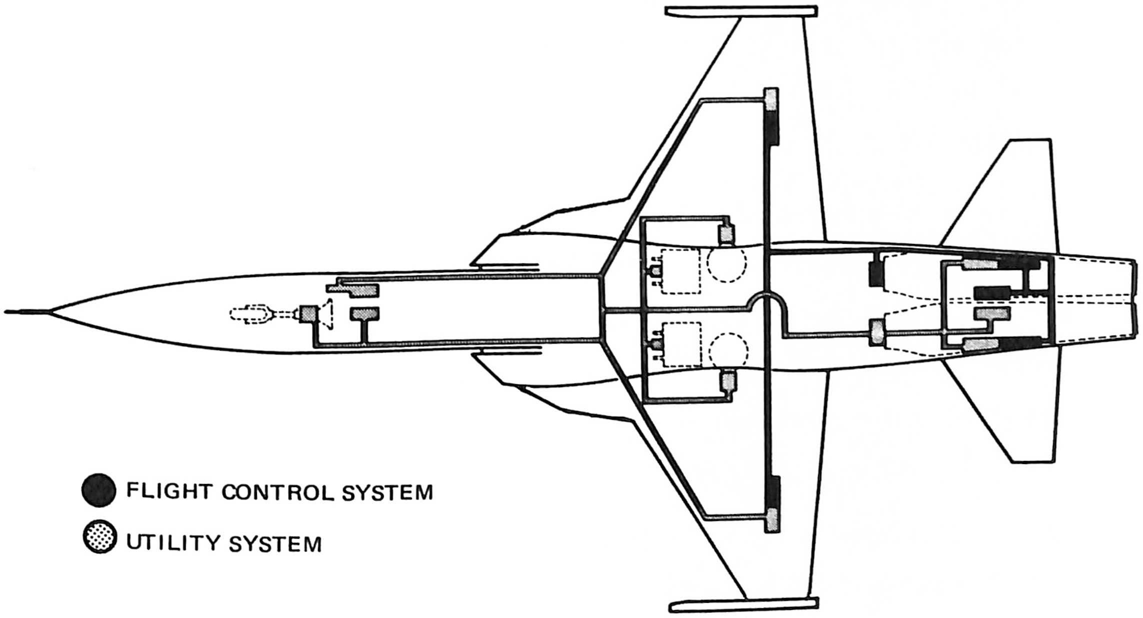


FIGURE 4-27. F-5E HYDRAULIC SYSTEMS

Through the use of dual or tandem actuators the output of each system is connected to each of the primary flight-control surfaces. The utility system provides a continuously operating backup for the flight control system. Should one system fail, the other provides uninterrupted flight control operation without pilot action or transfer. Operating alone, each system provides sufficient flight-control power for all but high-Mach-number maximum-roll maneuvers. In the event both engines fail, one windmilling engine will provide sufficient hydraulic power to maintain controlled flight during pilot evaluation of the engine emergency or during the restart procedure.

Both the flight control and utility hydraulic systems consist of: an engine-bleed-air pressurized reservoir with an oil capacity of 1.75 U.S. gallons (6.63 liters); a variable-delivery, engine-driven hydraulic pump; 10-micron pressure-and-return line filters (with replaceable elements); a pressure transmitter; ground test couplings, and the interconnecting lines. Maximum output of the hydraulic pump for each system is 8.5 gpm at 2600 psi, with a linear reduction in flow to zero gpm at 3000 psi. Each system is provided with a pressure indicator and low-pressure warning light in the cockpit (both cockpits in the F-5F). The light on the caution light panel comes on when the respective system pressure drops to 1500 psi or less and is extinguished when a pressure of approximately 1800 psi is restored. Reservoir fluid level is monitored through a window provided on the side of the aircraft without requiring removal of any access doors. Access to the filler cap for replenishing the reservoir is easily accomplished by removing a quick-opening access door.

## FLIGHT CONTROLS

Primary flight controls in the F-5E/F include ailerons, rudder and an all-movable horizontal stabilizer. The control system incorporates a system of springs and bobweights to provide the pilot with an artificial feel. Conventional control stick and rudder pedals (in both cockpits of the F-5F) are used to operate the flight control system through cables and pushrods to the servovalves which control the actuating cylinders. Two-axis, pitch and yaw, stability augmentation is provided.

The flight-control surfaces are operated by hydraulic actuators which are controlled by integral servovalves in response to manual commands by the pilot through the mechanical control system.

Hydraulic power for operation of the primary flight control actuators is provided through separate transmission lines by both the flight control and utility hydraulic systems. Two single actuators are provided at the rudder, one operated by each system. A dual actuator is provided at each aileron and two tandem actuators are provided for the horizontal stabilizer. In the case of these dual or tandem actuators, each hydraulic system operates a separate piston in the actuator, with no fluid interflow between the two systems. The actuators incorporate integral filters and pressure-relief valves.

Secondary flight controls include the speed brakes and wing leading and trailing-edge flaps.

## Control Stick

The control stick shown in Figure 4-28 is equipped with a standard grip incorporating a trim button, missile/bomb/rocket button, trigger, microphone/nosewheel steering button, a pitch damper cutoff switch, and a dogfight button for the fire control system. The trim button provides aileron and horizontal stabilizer trim which allows the pilot to reduce control forces to a minimum. Control stick movement beyond trim settings is achieved in flight by exerting force in the desired direction.

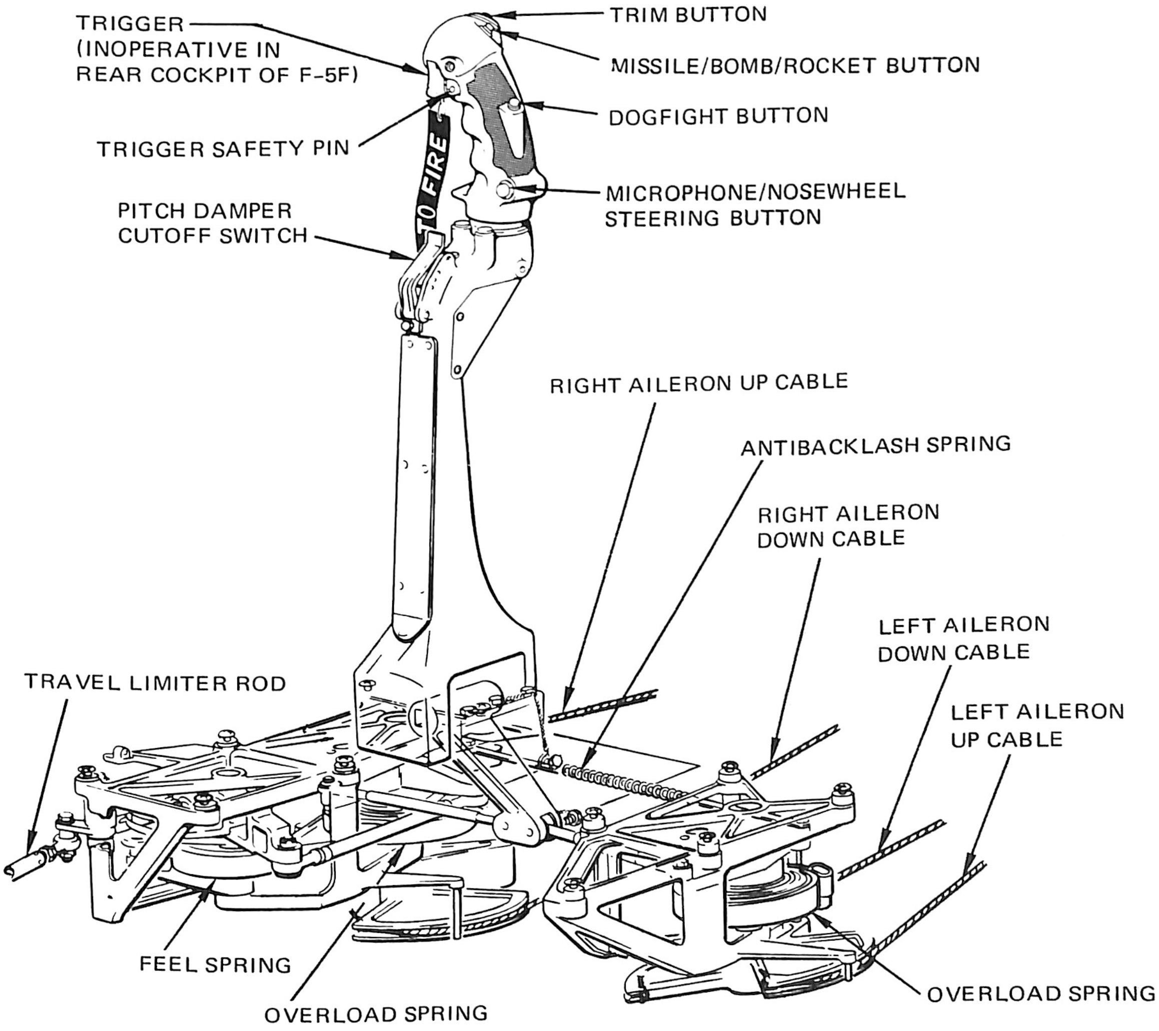

TRIGGER (INOPERATIVE IN REAR COCKPIT OF F-5F)
TRIM BUTTON
MISSILE/BOMB/ROCKET BUTTON
DOGFIGHT BUTTON
TRIGGER SAFETY PIN
TO FIRE
PITCH DAMPER CUTOFF SWITCH
MICROPHONE/NOSEWHEEL STEERING BUTTON
RIGHT AILERON UP CABLE
ANTIBACKLASH SPRING
RIGHT AILERON DOWN CABLE
LEFT AILERON DOWN CABLE
LEFT AILERON UP CABLE
TRAVEL LIMITER ROD
FEEL SPRING
OVERLOAD SPRING
OVERLOAD SPRING

FIGURE 4-28. F-5E/F CONTROL STICK

## Aileron Control System

The aileron control system presented in Figure 4-29 is actuated by the control stick located in the cockpit. Pushrods are connected through bellcranks and closed-cable systems to the valve operating-and-followup differential mechanism, mounted at the dual hydraulic actuator in each wing. Stick force is provided by an artificial-feel spring. Overload devices in each aileron system allow single aileron operation in case of binding in one aileron control. A centering mechanism attached to the output quadrant in each wing, centers the aileron in case of mechanical failure in the system. Aileron trim is provided by pushing a button on the control stick grip which energizes a screwjack actuator mounted at the feel spring. An aileron limiter, mechanically positioned by retraction of the nose landing gear, provides a spring detent which limits the aileron travel to a safe value for high-speed flight. The spring detent may be overridden in an emergency. Table 4-2 lists the operational limits for the aileron control system.

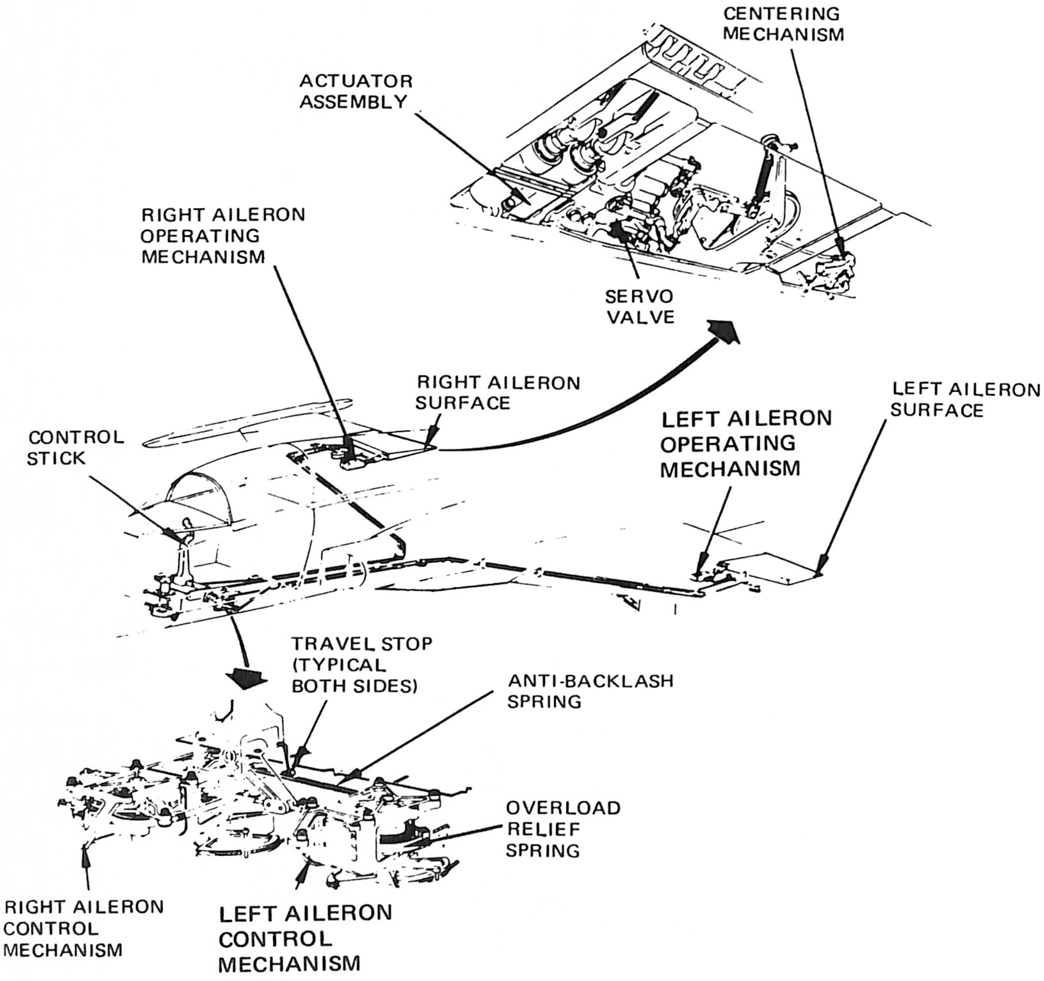

CENTERING MECHANISM
ACTUATOR ASSEMBLY
RIGHT AILERON OPERATING MECHANISM
SERVO VALVE
RIGHT AILERON SURFACE
LEFT AILERON SURFACE
CONTROL STICK
LEFT AILERON OPERATING MECHANISM
TRAVEL STOP (TYPICAL BOTH SIDES)
ANTI-BACKLASH SPRING
OVERLOAD RELIEF SPRING
RIGHT AILERON CONTROL MECHANISM
LEFT AILERON CONTROL MECHANISM

FIGURE 4-29. F-5E/F AILERON CONTROL SYSTEM

TABLE 4-2. AILERON CONTROL LIMITS

| LIMITS | CONTROL |
|---|---|
| STICK TRAVEL | GEAR UP ± 3.2 INCHES EACH DIRECTION<br>GEAR DOWN ± 4.0 INCHES EACH DIRECTION |
| AILERON TRAVEL | GEAR UP 18.5 DEGREES UP, 14 DEGREES DOWN<br>GEAR DOWN 35 DEGREES UP, 25 DEGREES DOWN |
| AILERON TRIM | 12-DEGREES DIFFERENTIAL |

### Stability Augmenter System

The F-5E/F aircraft are equipped with a two-axis stability augmenter system to improve damping of the longitudinal short period and the lateral-directional short period (Dutch roll) modes. The aircraft can be flown safely without augmentation if a system malfunction occurs.

The augmenter system is engaged or disengaged by toggle switches (identified as PITCH and YAW) on the control panel, located on the left console in the cockpit (front cockpit only in the F-5F). The pitch axis of the augmenter can also be disengaged by an actuating lever mounted on the stick, forward of and below the grip (both cockpits in the F-5F). The yaw axis of the augmenter also provides rudder trim capability by using the control knob located adjacent to the toggle switches on the control panel.

Two identical rate gyros are used to sense aircraft body axis angular rates, one about the vertical axis for yaw and another about the transverse axis for pitch. Signals from the rate gyros are shaped to produce the desired characteristics in the electronic components assembly, and are combined with the servoactuator position feedback signals. The combined signal is then amplified to drive the servoactuators. Gain scheduling with indicated airspeed (compressible dynamic pressure) is accomplished through variable resistors located in the CADC.

The augmenter uses limited authority electrohydraulic servoactuators that assume a neutral center position on disengagement and can be overridden by pilot action. Each of the two servoactuators incorporates an electrohydraulic servovalve and a feedback position transducer. One actuator is in series with each mechanical control system (rudder and horizontal stabilizer) to provide stability augmentation by modifying the pilot's mechanical control inputs. When not in operation, the servoactuators act as a fixed link in the mechanical controls. Hydraulic power to each servoactuator is supplied through solenoid-operated valves.

### Rudder Control System

The rudder control system uses conventional rudder pedals located in the cockpit(s) as shown in Figure 4-30. Pushrods are connected through bellcranks and a closed-cable system, to the dual hydraulic actuators mounted at the control surface. Pedal forces are provided by an artificial-feel type spring. A rudder pedal adjustment T-handle is located on the cockpit pedestal for repositioning the pedals. Rudder trim is obtained by electrical biasing of the yaw axis stability augmenter actuator, that is mounted in series with the control system. The trim control knob is mounted on the left-hand console in the cockpit (front cockpit only in the F-5F). Rudder authority is available up to ±30 degrees as a function of dynamic pressure. Hydraulic power to the rudder actuators is regulated at 1500 psi in both the utility and flight control hydraulic systems. Table 4-3 specifies the control limits for the rudder control system.

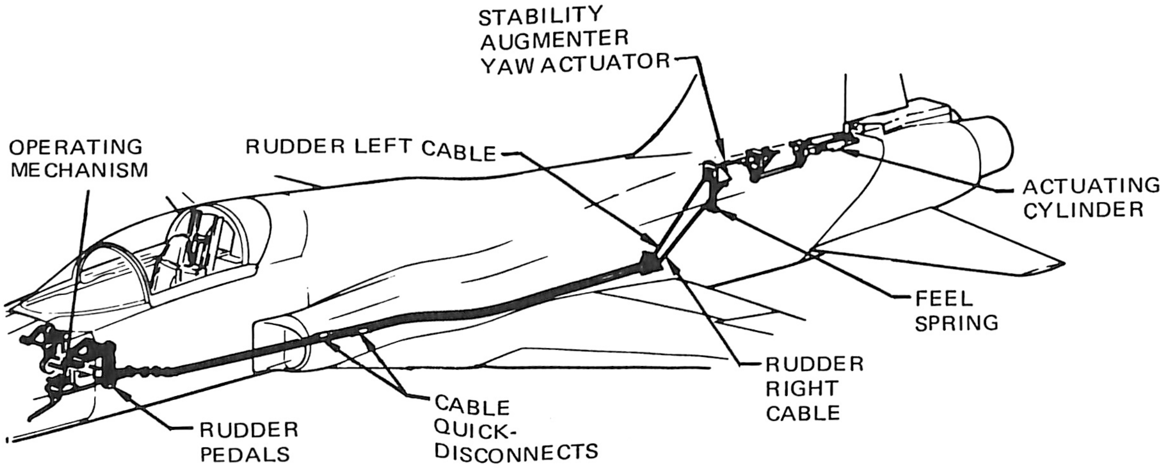

STABILITY AUGMENTER YAW ACTUATOR
OPERATING MECHANISM
RUDDER LEFT CABLE
ACTUATING CYLINDER
FEEL SPRING
RUDDER RIGHT CABLE
RUDDER PEDALS
CABLE QUICK-DISCONNECTS

FIGURE 4-30. F-5E/F RUDDER CONTROL SYSTEM

TABLE 4-3. RUDDER CONTROL LIMITS

| CONTROL | LIMIT |
|---|---|
| PEDAL TRAVEL (MAXIMUM) | ±3.52 INCHES |
| RUDDER TRAVEL (MAXIMUM) | ±30 DEGREES |
| YAW-AUGMENTER RUDDER TRAVEL | ±6 DEGREES |
| RUDDER TRIM RANGE | ±4 DEGREES |

### Horizontal Stabilizer Control System

The horizontal stabilizer control system presented in Figure 4-31 is actuated by the conventional control stick in the cockpit(s), geared through pushrods, linkage, and a dual tension-regulated closed-cable system which actuates a differential mechanism mounted in the aft section of the airplane. The differential mechanism is connected through an overload bungee to a walking beam which drives a closed-cable system interconnecting dual hydraulic tandem surface actuators. Stick forces are provided by a stick-mounted bob-weight and an artificial-feel type spring mounted in the aft section.

Trim is obtained through a screwjack-type actuator. Takeoff trim is selected by use of the trim button on the control stick grip (both cockpits in the F-5F). The selected trim position is displayed on the trim indicator located on the left instrument panel. Table 4-4 specifies the control limits for the horizontal stabilizer control system.

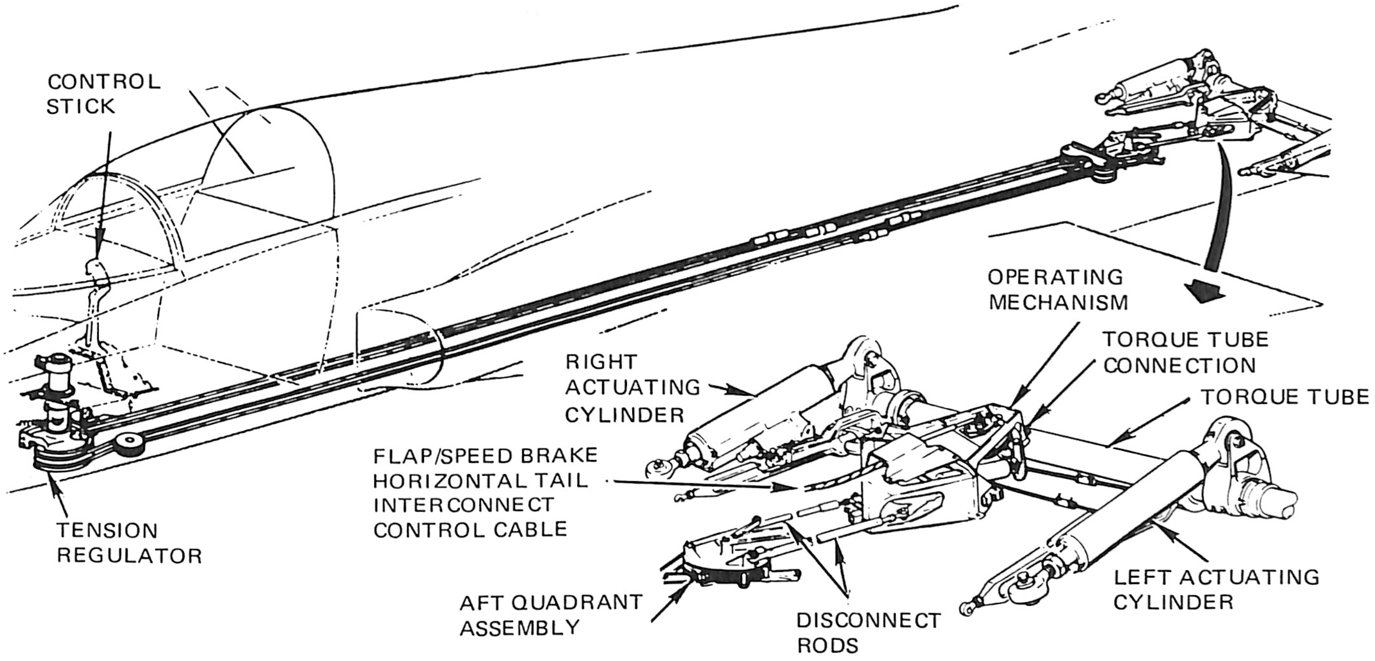

CONTROL STICK
TENSION REGULATOR
RIGHT ACTUATING CYLINDER
FLAP/SPEED BRAKE HORIZONTAL TAIL INTERCONNECT CONTROL CABLE
AFT QUADRANT ASSEMBLY
DISCONNECT RODS
OPERATING MECHANISM
TORQUE TUBE CONNECTION
TORQUE TUBE
LEFT ACTUATING CYLINDER

FIGURE 4-31. F-5E/F HORIZONTAL STABILIZER CONTROL SYSTEM

TABLE 4-4. HORIZONTAL STABILIZER CONTROL SYSTEM LIMITS

| CONTROL | LIMIT |
|---|---|
| STICK TRAVEL | F-5E 8.4 INCHES AFT, 3.2 INCHES FWD<br>F-5F 8.8 INCHES AFT, 3.2 INCHES FWD |
| HORIZONTAL STABILIZER TRAVEL (T.E.) | F-5E 17 DEGREES UP, 5.0 DEGREES DOWN<br>F-5F 20 DEGREES UP, 5.0 DEGREES DOWN |
| HORIZONTAL STABILIZER TRIM RANGE (T.E.) | 8.5 DEGREES UP, 0.2 DEGREE DOWN |
| PITCH AUGMENTER HORIZONTAL STABILIZER TRAVEL (T.E.) | 1.5 DEGREES UP, 1 DEGREE DOWN |

### Speed Brake System

The speed brake control system includes directional, relief, and rate-control hydraulic valves, together with two actuating cylinders. The cockpit control (both cockpits in the F-5F) consists of a thumb actuated three-position detented switch incorporating open, close, and off positions and is mounted on the right-hand power control lever. By short intermittent actuation, any degree of speed brake extension between closed and fully-open can be selected. Maximum speed brake extension is 45 degrees from the airplane horizontal reference line except with any centerline store when the maximum deflection is 30 degrees to the HRL. The presence of the centerline store is automatically sensed. The speed brake is a variable position type which requires approximately 4 seconds to open and 3 seconds to close. At high air speeds the speed brake may not fully extend, but as air speed decreases it moves out to a fully extended position.

A mechanical system interconnects the flaps and speed brake to the horizontal stabilizer mechanism in the aft fuselage as shown in Figure 4-32. This arrangement produces automatic pitch trim compensation. The interconnection is a series input to the horizontal stabilizer system which does not change the control stick position.

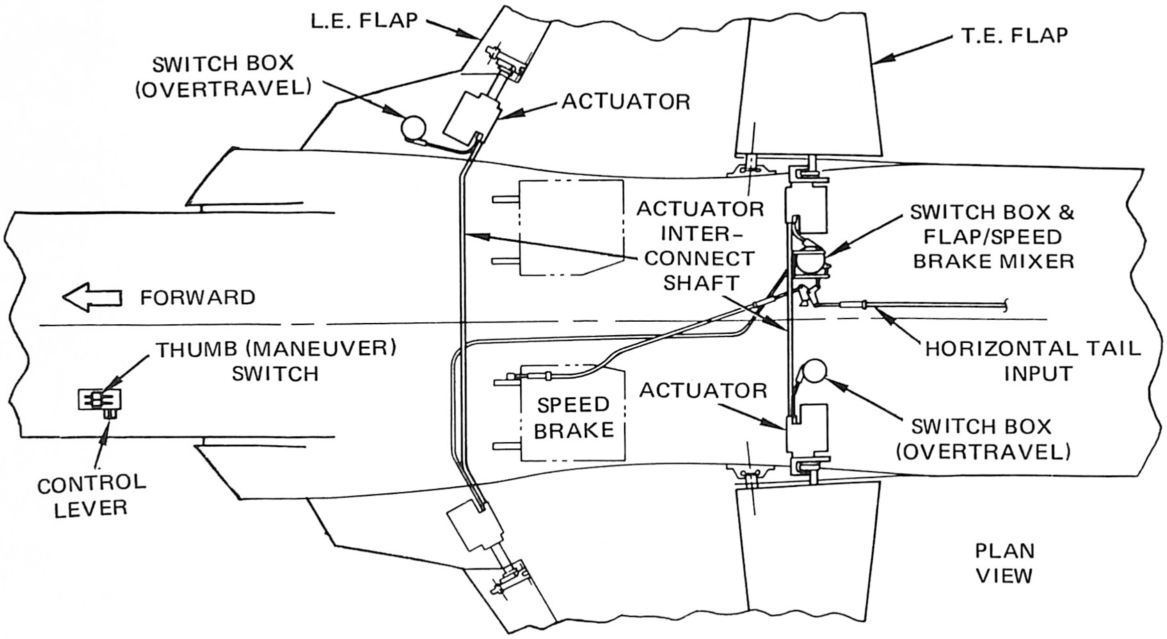

L.E. FLAP
SWITCH BOX (OVERTRAVEL)
ACTUATOR
T.E. FLAP
ACTUATOR INTER-CONNECT SHAFT
SWITCH BOX & FLAP/SPEED BRAKE MIXER
FORWARD
THUMB (MANEUVER) SWITCH
HORIZONTAL TAIL INPUT
SPEED BRAKE
ACTUATOR
SWITCH BOX (OVERTRAVEL)
CONTROL LEVER
PLAN VIEW

**FIGURE 4-32. F-5E/F FLAP/SPEED BRAKE – HORIZONTAL TAIL INTERCONNECT**

### Flap System

Leading edge and trailing edge flaps provide additional lift for takeoff and landing, additional load factor capability for maneuvering and reduced drag for cruise. Figure 4-33 depicts flap settings for full flaps, maneuver, cruise and supersonic flight. Full flaps (leading edge 24 degrees with trailing edge 20 degrees) are used for takeoff and landing below 330 KIAS or 0.85 Mach number and low speed maneuvering below 200 KIAS. Partial flaps are used for high speed maneuvering up to 550 KIAS or 0.95 Mach number. The high speed maneuvering (CR) setting is 0 degrees leading edge with 8 degrees trailing edge. The maneuvering flap deflection (M) is 24 degrees leading edge with 20 degrees trailing edge below 200 KIAS, 18 degrees leading edge with 16 degrees trailing edge between 200 and 250 KIAS, and 12 degrees leading edge with 8 degrees trailing edge between 250 KIAS and 550 KIAS or 0.95 Mach number. The time for full flap travel varies between five and ten seconds depending on engine RPM. The flap settings specified provide improvements in sustained turn rates, high lift handling qualities, maximum lift, and reduction of buffet intensity at maximum load factors.

There are two flap controls, the main flap control lever mounted aft and outboard of the power control (throttle) levers and the thumb switch mounted on the right throttle lever (Figures 4-20 and 4-21). The flap control levers in the F-5F are mechanically interconnected to provide full control from either cockpit. The main flap control lever has three positions, EMER UP (emergency up), THUMB SW (thumb switch) and FULL. The EMER UP and FULL positions are controlled by dual control circuitry to allow the flap to be positioned at the full up or down position in the event of a single electrical control circuit failure. The thumb switch on the throttle lever controls the position of the flaps when the main flap lever is at the THUMB SWITCH position. The thumb switch has three positions M (maneuver), CR (cruise)* and UP and has single control circuitry. The thumb switch in the rear cockpit of the F-5F has four positions, M, CR, UP, and TR (transfer). The TR position must be selected to enable thumb switch control in the front cockpit. Movement out of the TR position puts maneuvering flap mode selection under rear cockpit control.

In the M setting, the flaps are automatically positioned by signals from the CADC. Above 550 KIAS or 0.95 Mach number (whichever is lower), switches in the CADC prevent lowering of the flaps with the thumb switch, or if they are already down, initiate

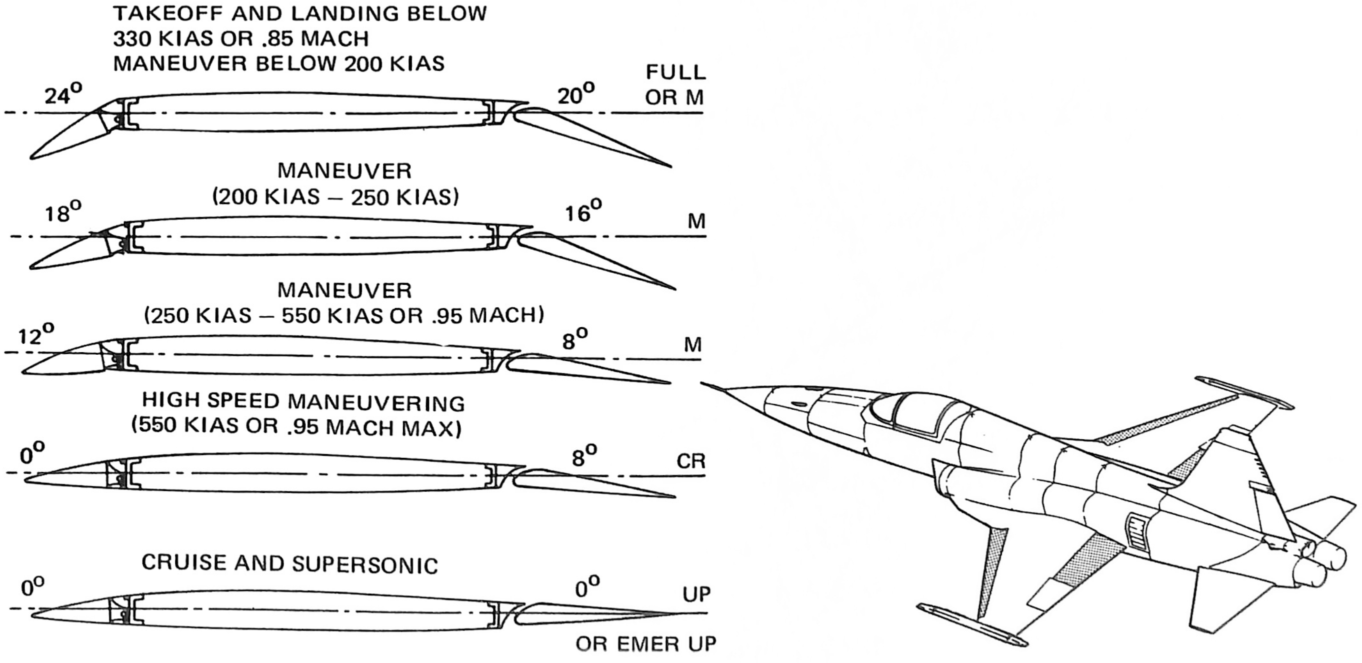

TAKEOFF AND LANDING BELOW
330 KIAS OR .85 MACH
MANEUVER BELOW 200 KIAS
24°
20°
FULL
OR M
MANEUVER
(200 KIAS – 250 KIAS)
18°
16°
M
MANEUVER
(250 KIAS – 550 KIAS OR .95 MACH)
12°
8°
M
HIGH SPEED MANEUVERING
(550 KIAS OR .95 MACH MAX)
0°
8°
CR
CRUISE AND SUPERSONIC
0°
0°
UP
OR EMER UP

FIGURE 4-33. F-5E/F FLAP POSITIONS

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*CR position (0°/8°) is recommended only for high speed maneuvering. Optimum cruise setting is UP (0°/0°).

an audio warning tone to the pilot's headset and a "Barber Pole" warning on the flap position indicator. The audio warning can be silenced by using the warning silence button next to the landing gear lever.

A five-position indicator on the instrument panel indicates UP, CR, M, FULL and "Barber Pole." ("Barber Pole" indicates that the flaps are between selected positions or that the flaps are down above the flap limit speed).

Each leading edge and trailing edge flap is driven by a rotary electrical actuator located at the inboard end of the flap. Left and right actuators are interconnected by rotary flex shafts to prevent asymmetry and to provide single actuator operation capability. Each actuator is powered by an independent 115 vac, 3-phase 320 to 480 Hz power circuit. Dual independent circuits incorporated in each actuator allow normal operation in the event of a single failure.

Mechanical stops are provided in each leading edge and trailing edge actuator. Limit switches are located in the switch units interconnected with the actuators by rotary flex shafts. Leading and trailing edge flaps are individually mechanically interconnected to the horizontal stabilizer to provide automatic trim compensation when flaps are used (Figure 4-32). The flap control system is shown in Figure 4-34.

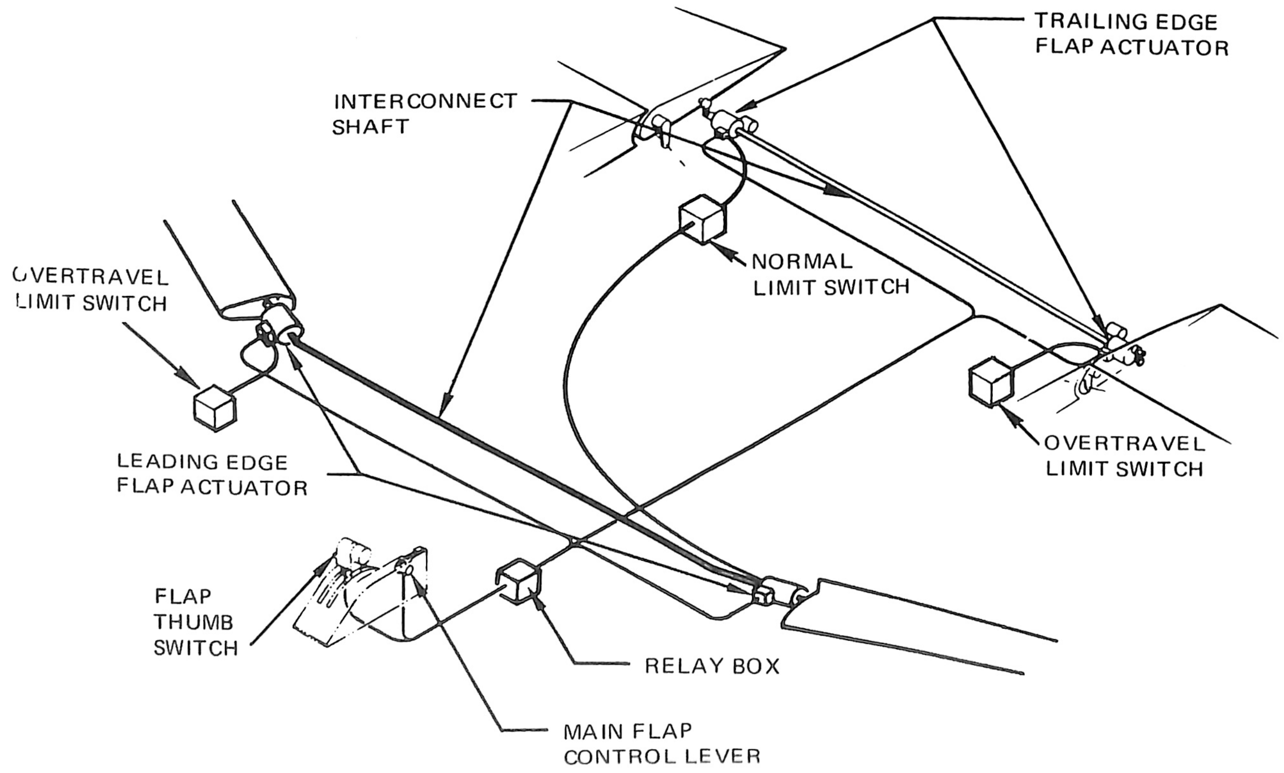
TRAILING EDGE FLAP ACTUATOR
INTERCONNECT SHAFT
OVERTRAVEL LIMIT SWITCH
NORMAL LIMIT SWITCH
OVERTRAVEL LIMIT SWITCH
LEADING EDGE FLAP ACTUATOR
FLAP THUMB SWITCH
RELAY BOX
MAIN FLAP CONTROL LEVER

FIGURE 4-34. F-5E/F FLAP CONTROL SYSTEM

# LANDING SYSTEM

## Landing Gear

The F-5E/F aircraft are equipped with a hydraulically operated tricycle landing gear, designed for a 26,000 pound maximum gross takeoff weight.* It is controlled from a panel at the lower left of the cockpit instrument panel as shown in Figure 4-35 (both cockpits in the F-5F). The landing gear extending, locking, and retracting functions are hydraulically powered by the utility hydraulic system as is the nose wheel steering, main wheel braking and nose gear hiking/dehiking. The hydraulic door actuators are electrically sequenced to actuate the nose and main wheel doors to the closed position except during gear actuation. The strut doors are linked to their respective struts and are positioned by the motion of the strut.

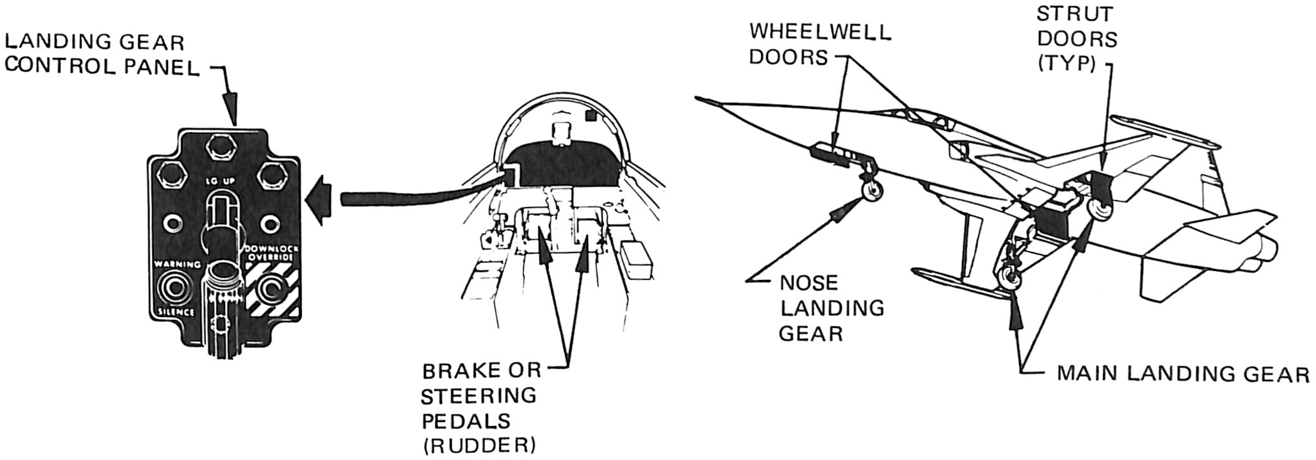

FIGURE 4-35. F-5E/F LANDING GEAR SYSTEM

A mechanical linkage (front cockpit only in the F-5F) and cable system is provided to release the gear doors and landing gear uplocks in the event of utility hydraulic system failure. The wheel braking system automatically assumes a manual mode of operation if utility hydraulic system pressure is lost.

The landing gear control panel has three green indicator lights for gear-position, which illuminate only when their respective gears are down and locked. The nose gear is lengthened (hiked) for improved takeoff performance by actuating a switch on the left-hand horizontal console (front cockpit only in the F-5F). The gear automatically shortens (dehikes) when gear retraction is selected. The landing gear lever cannot be moved from the LG DOWN to LG UP position when the aircraft is on the ground unless the landing gear DOWNLOCK OVERRIDE button is pressed and held.

When the landing gear control handle is moved to the up position, a red warning light in the handle indicates that the gears and doors are cycling, and alerts the pilot to any gear or gear door that is not up and locked at the completion of the cycle. When all gears and gear doors are up and locked, the red warning light and an audible signal operate to alert the pilot to lower the gear when the following conditions exist: airspeed is below 210 ±10 knots; altitude is below 10, 000 ±250 feet; and either power control lever is set below the 96 percent rpm position. These warning devices also operate when the landing gear control handle is down and any gear is not down and locked. The audible signal may be silenced by pressing the WARNING-SILENCE button on the landing gear control panel. These warning devices may be tested by actuating the TEST switch on the lighting control panel located on right-hand console (both cockpits in the F-5F). The signal will be heard in the pilot's headset, regardless of the setting of the intercommunication system controls. The maximum permissible airspeed with the landing gear extended is 260 KIAS.

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*Maximum qualified loading F-5F gross weight is 24,382 pounds, 1618 pounds below the gear design limit.

Main Landing Gear. The main gear consists of a right- and left-hand assembly with essentially identical features. Each gear consists of a shock strut, side brace, strut door, inboard door, appropriate locks, a retracting mechanism, and the wheel, brake, and tire assembly all shown in Figure 4-36.

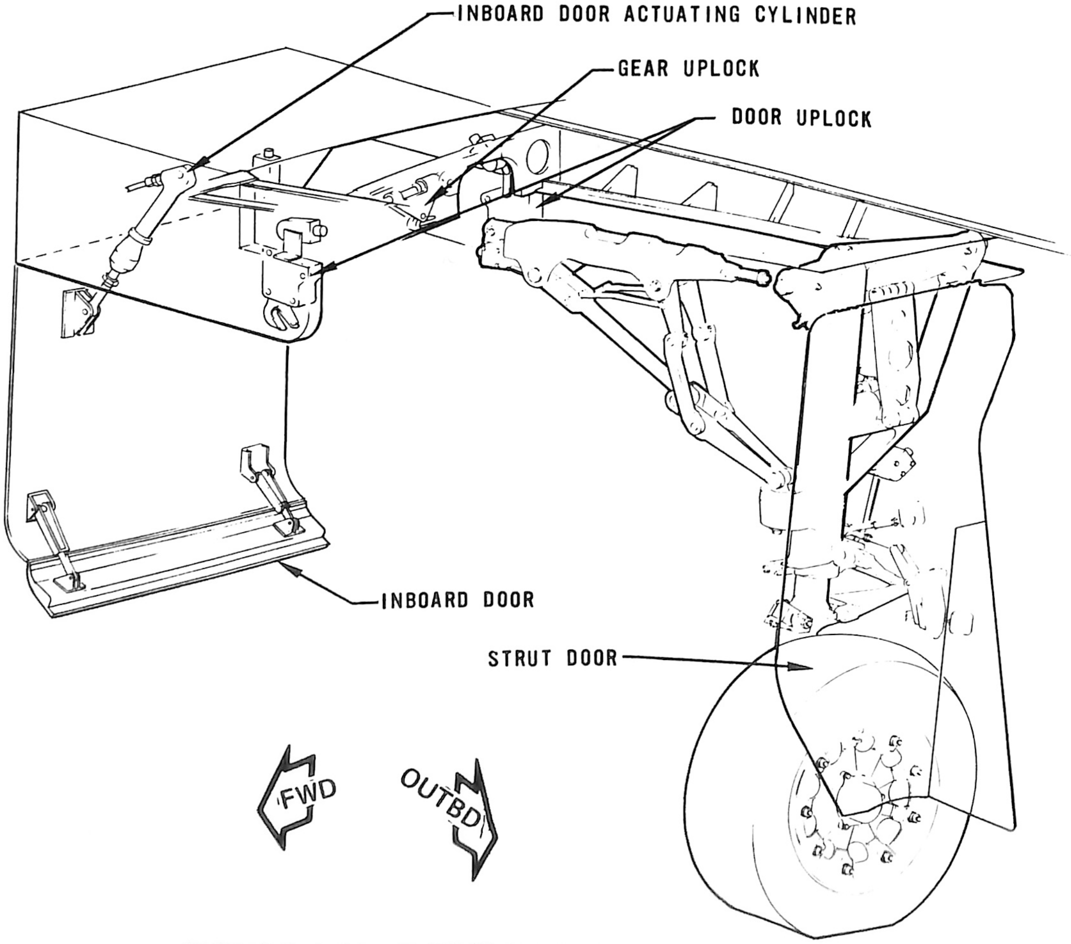


FIGURE 4-36. F-5E/F MAIN LANDING GEAR

The inboard wheelwell door, which is normally actuated and locked hydraulically, is electrically sequenced to close when the main landing gear is fully extended and locked or retracted and locked. One exception occurs when the alternate release system is used to extend the landing gear. In this case, the T-handle at the control panel mechanically releases the main gear uplocks and main gear inboard door uplocks, and gravity plus airloads open the doors and extend the gear. The landing gear is assisted into a downlocked overcenter position by spring bungees. When the alternate release system is actuated, switches in this system disconnect electrical power from the gear and gear door selector valves. Another exception is when the inboard door is actuated for ground access by operation of a switch located in the right-hand main wheelwell.

Each main gear shock strut is hinged at its upper end to fittings mounted on a wing rib. The gear is stabilized in the spanwise direction by a side brace attached to the 44-percent wing spar at the top and the shock strut at the lower end. The side brace folds at its center joint and rolls aft to retract the gear inboard. Normal actuation of the mechanism is accomplished by hydraulic cylinders. A separate hydraulically-operated uplock holds the gear in the up position. The gear is locked in the down position by an overcenter linkage in the side brace mechanism, and hydraulic pressure is maintained on the gear. Each main gear has an integral hinged jack pad. The main gear shock absorbers are of the conventional air-oil type, with energy capacity to allow landing a 15, 000-pound aircraft at a 10-foot-per-second sink rate and a 24, 000-pound aircraft at a 5-foot-per-second sink rate.

The wheel brakes are powered by pressure from the aircraft utility hydraulic system and controlled by motion of the brake (rudder) pedals in the cockpit. The brake system consists of two brake control valves in the cockpit and a multiple-disk brake assembly rigidly attached to each main gear strut. Integral brake wear adjusters in each brake assembly automatically compensate for brake lining wear.

In a normal mode of operation, depressing the brake pedals in the cockpit rotates the linkage to depress the brake control valve actuating plunger which meters utility hydraulic system pressure to the wheel brake assembly as shown in Figure 4-37. This hydraulically-actuated piston moves against a pressure plate forcing stator and rotor disks into contact to provide braking friction. The magnitude of hydraulic pressure applied to each wheel brake is proportional to the force applied to the brake pedals. When the brake pedals are released, internal spring action within the brake control valve repositions valve mechanisms shutting off the utility hydraulic system pressure to the wheel brakes. This allows hydraulic pressure in the brake pressure line to be ported to the utility hydraulic system return. With hydraulic braking pressure relieved, the integral return springs in the wheel brake housing return the brake disks to the brake-off position. If utility hydraulic system pressure is lost, the brake control valves automatically assume a manual mode of operation and function as brake master cylinders.

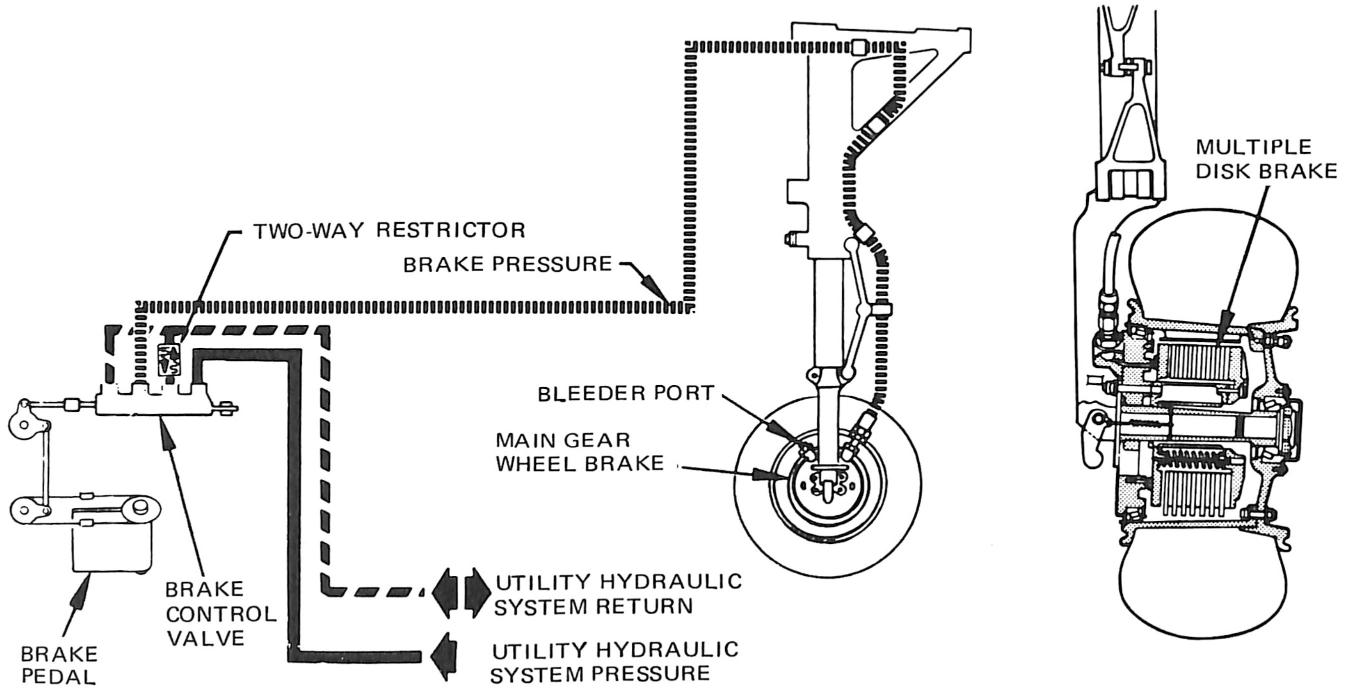

MULTIPLE DISK BRAKE
TWO-WAY RESTRICTOR
BRAKE PRESSURE
BLEEDER PORT
MAIN GEAR WHEEL BRAKE
UTILITY HYDRAULIC SYSTEM RETURN
UTILITY HYDRAULIC SYSTEM PRESSURE
BRAKE CONTROL VALVE
BRAKE PEDAL

FIGURE 4-37. WHEEL BRAKE SYSTEM

The brake is qualified for the following:

- Forty-five full stop landings, each including three taxi stops from thirty knots at a landing weight of 15, 000 pounds, without the use of the drag chute.
- Five full stop landings, each including three taxi stops from thirty knots at maximum landing weight of 22, 000 pounds, with the use of the drag chute.
- One rejected-takeoff full stop, including three taxi stops from thirty knots at an aircraft weight of 26, 000 pounds, with use of the drag chute.

Each wheel is equipped with fuse plugs to prevent wheel/tire explosions, in case of brake overheat.

Nose Landing Gear. The nose gear presented in Figure 4-38 consists of a conventional air-oil type shock strut with a two-position hiking cylinder, retracting mechanism, steering mechanism, strut door, forward door, appropriate locks, and the wheel and tire assembly. The nose gear has an energy capability compatible with a three-point landing at an aircraft weight of 15,000 pounds for a 10-foot-per-second sink rate and an aircraft weight of 24,000 pounds for a 5-foot-per-second sink rate.

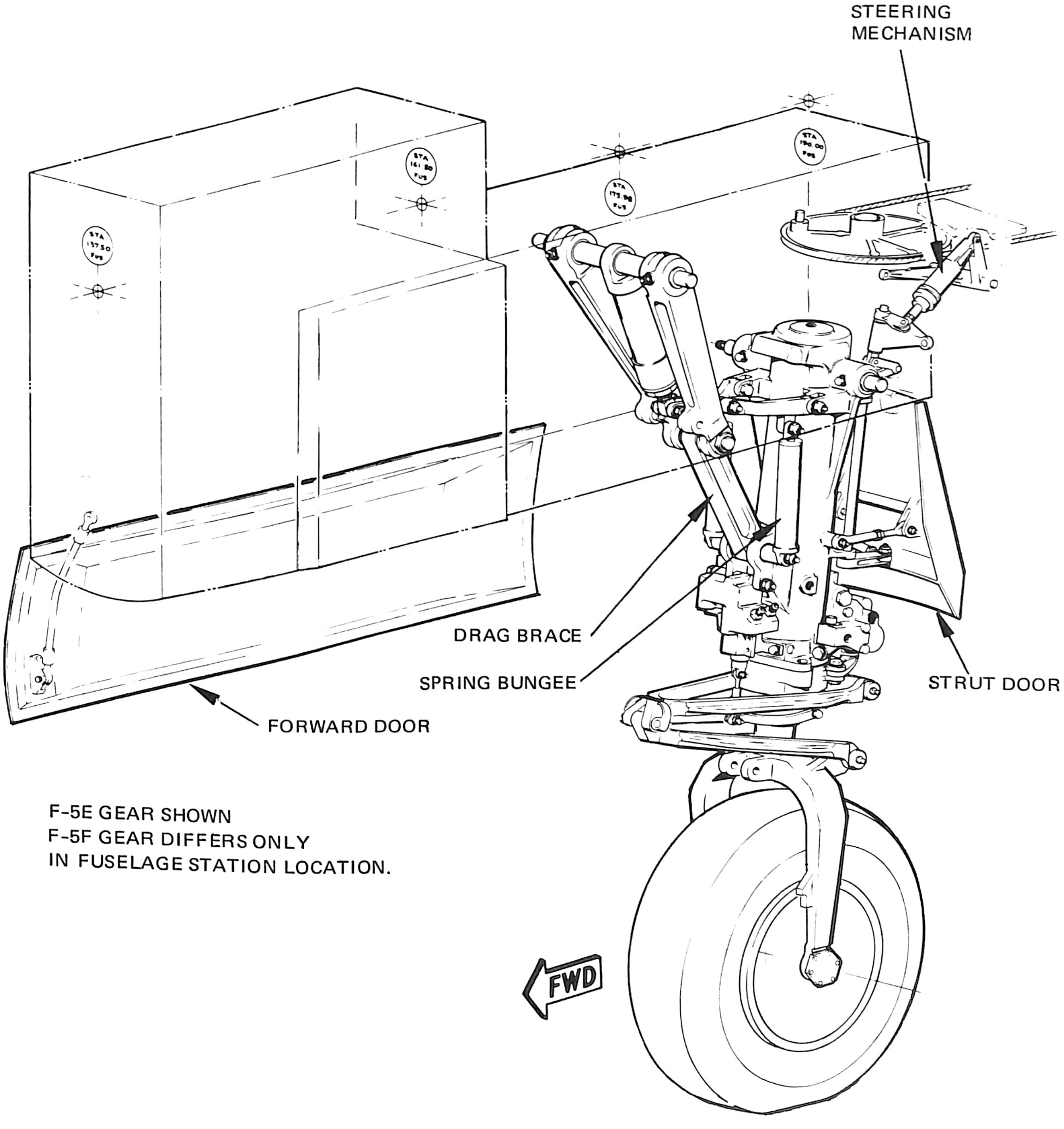

STEERING MECHANISM
DRAG BRACE
SPRING BUNGEE
STRUT DOOR
FORWARD DOOR
F-5E GEAR SHOWN
F-5F GEAR DIFFERS ONLY
IN FUSELAGE STATION LOCATION.
FWD

FIGURE 4-38. F-5E/F NOSE LANDING GEAR (STATIC POSITION, DEHIKED)

The forward door is hinged on the right side of the wheel well and the aft door is linked to the strut. The forward door is actuated and locked hydraulically, and is electrically sequenced to close when the nose gear is fully extended and locked. Exceptions to this procedure occur when the alternate release system is used to extend the gear or the ground switch in the right-hand wheel well is actuated.

The nose strut is hinged at its upper end and retracts forward into the wheel well. A drag brace, forward of the gear, is hinged at the upper end to the fixed structure and to the strut at its lower end. The drag brace folds at its center joint to retract the gear. The overcenter-lock linkages are hydraulically operated to lock the gear in either the down or retracted position. An alternate mechanical system is provided to release the mechanism and allow the nose gear to extend to the down position by gravity, airloads and spring forces.

When the nose gear is down and locked on the ground, it can be lengthened (hiked) 13.0 inches at the option of the pilot. The hiked gear provides a nose-up airplane attitude of approximately 3.4 degrees (3.7 degrees in F-5F) which contributes to reduced takeoff roll. The nose gear can be dehiked at the option of the pilot, and is automatically dehiked for stowage in the wheel well upon gear retraction.

Nosewheel steering is controlled by movement of the rudder pedals and is available when the weight of the aircraft is on the right main gear. Power is obtained by pressing and holding the nosewheel steering switch on the control stick grip (both cockpits in the F-5F). The electrically energized steering system is powered by pressure from the utility hydraulic system, and provides a nosewheel turning angle up to 40 degrees either side of center. This produces the taxi turning radii shown in Figure 4-39.

| TURNING RADIUS (FT) | | |
|---|---|---|
| | F-5E | F-5F |
| ① LEFT MAIN WHEEL | 13.7 | 18.6 |
| ② RIGHT MAIN WHEEL | 26.8 | 31.8 |
| ③ HORIZONTAL TAIL | 29.7 | 34.2 |
| ④ MISSILE FIN | 34.5 | 39.4 |
| ⑤ NOSE BOOM | 36.9 | 42.7 |

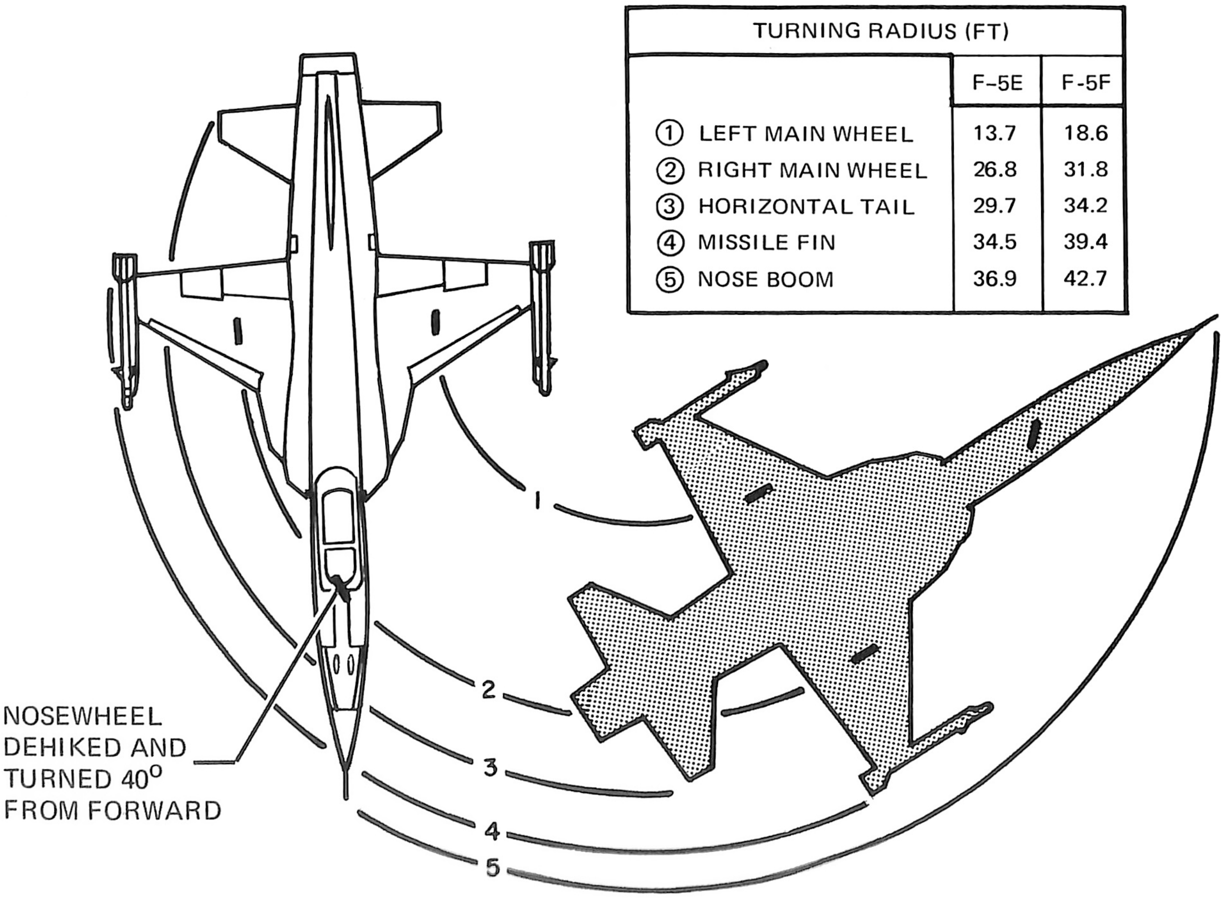


FIGURE 4-39. TAXI TURNING RADIUS

Releasing the control stick steering switch immediately deenergizes the nosewheel steering function, and the hydraulic steering unit reverts to a shimmy dampening function. If the alternate landing gear release system has been actuated, the nosewheel steering system is deactivated completely. A steering disconnect at the torque link apex permits 360-degree steering rotation of the nosewheel for towing purposes.

### Tires

The main landing gear tires are 24 x 8.0-13, tubeless Type VIII with fabric-reinforced tread. The tires are rated for a 12,500-pound static load each and a 250-mph maximum speed. The nosewheel tire is an 18 x 6.5-8, 12-ply rating, tubeless Type VIII with fabric-reinforced tread. The wheel and tire are rated for a 5,000-pound static load and 250-mph maximum speed. The required tire pressures are determined by the specific airplane loading configuration for takeoff, and range from 200 to 285 psi on the main landing gear and from 95 to 120 psi on the nose gear. The LCN (Load Classification Number) is approximately 10. This number will vary slightly depending on tire pressure and wheel load.

### Drag Chute System

A 15-foot-diameter drag chute is provided for the F-5E/F aircraft. The drag chute compartment is located on top of the aft fuselage and the door is aft and below the rudder. The compartment is air-cooled to prevent overheating of the chute, and sealed to prevent internal icing. The chute is hand packed; no special packing equipment is required.

The chute release mechanism shown in Figure 4-40 is entirely mechanical and independent of any other aircraft system. A T-handle, located adjacent to the upper left-hand side of the instrument panel (both cockpits in the F-5F), initiates drag chute release. Maximum deployment speed for the chute is 165 KIAS. The drag chute is not physically connected to the aircraft until the T-handle is extended. Subsequent rotation clockwise and further extension of the T-handle jettisons the chute.

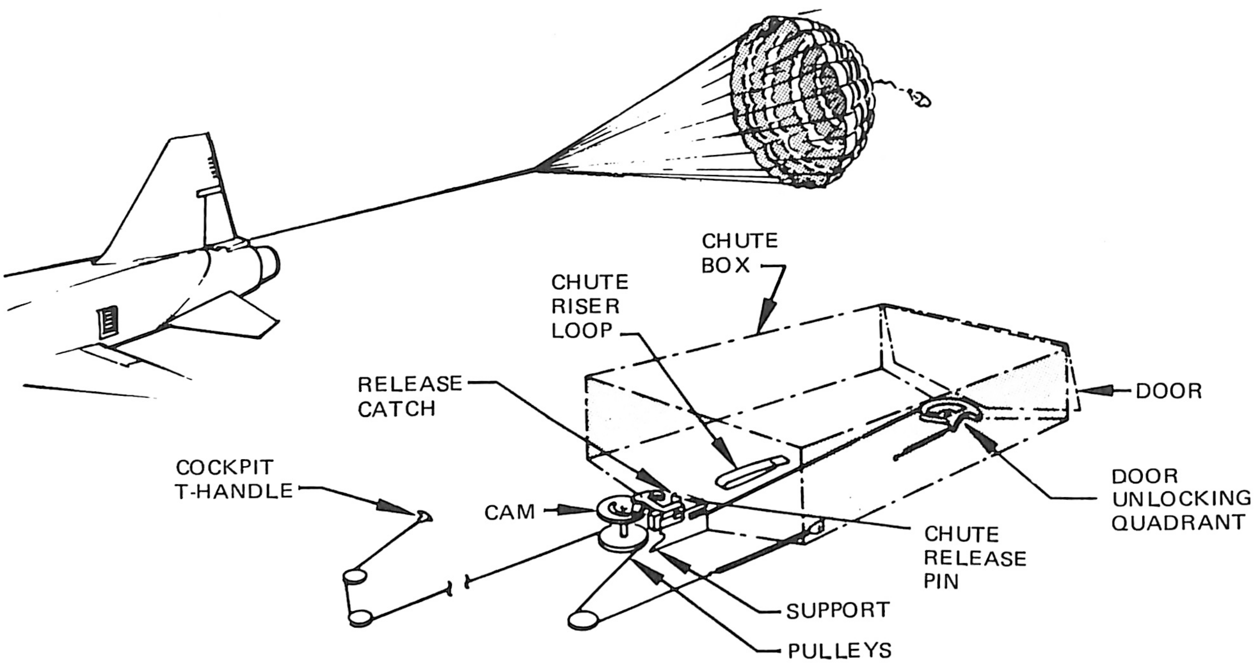


FIGURE 4-40. DRAG CHUTE SYSTEM

### Arresting Hook

An emergency arresting hook system is provided for use with most commonly used barrier equipment having a cable diameter of 1.24 inches or less. The hook is shown in the extended position in Figure 4-41. The limit hook load capability of the system is 57,000 pounds. This will allow maximum gross weight arrestments at between 140 and 160 knots depending on the barrier. BAK 9, BAK 12, or comparable barriers are compatible with the system. The hook is attached on the lower fuselage centerline at approximately FS 455 and has ±20 degree lateral movement. The attach structure is designed to withstand the 57,000-pound load applied within a 20-degree cone.

A cup-guarded switch with a yellow light in the button to indicate hook down is provided on the left side of the main instrument panel near the landing gear control lever (both cockpits in the F-5F). The hook is released from the stowed position by an electric solenoid powered by either the AC or DC system and lowered by a set of torsion bar springs. If the nose gear is in the hiked position (as it may be in the case of an aborted takeoff), actuation of the hook switch also dehikes the nose gear. Electrical interlock with the landing gear control lever position allows hook extension only when the landing gear control is down or the landing gear alternate release is actuated. An up-stop bumper is provided to prevent damage to the fuselage from hook snap-up at engagement. Hook bounce on the runway is controlled by a self-contained hydraulic snubber. Since the hook is manually stowed, a retraction control is not required. A quick release is provided so the hook can be lowered for access to the fuselage service doors.

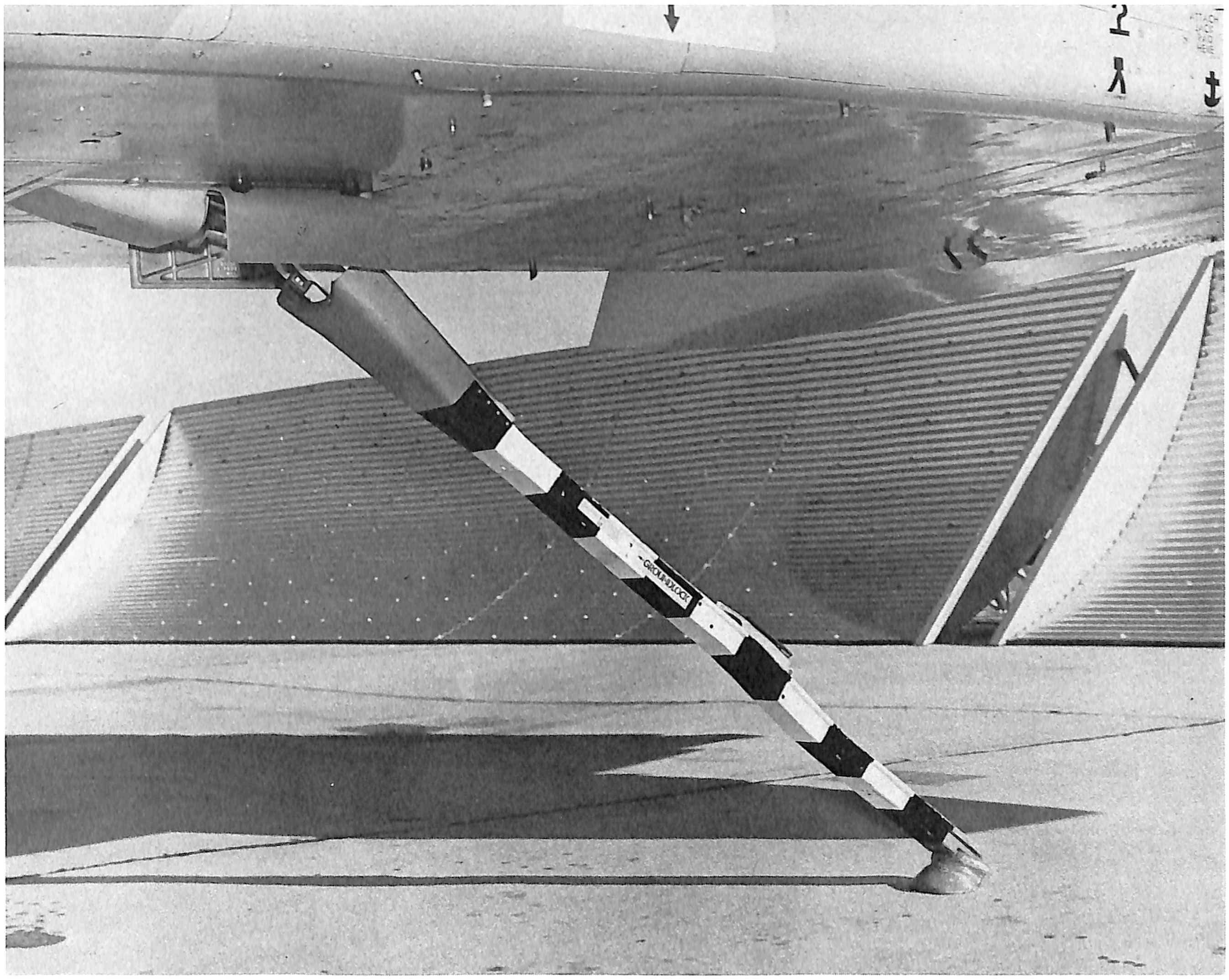


FIGURE 4-41. ARRESTING HOOK

## ELECTRICAL POWER SYSTEM

### AC System

Alternating current electrical power for the F-5E/F is provided by two 13/15 kva, 115/200 volt, three-phase, 320/480 Hz nonparalleled generator systems as shown in Figures 4-42 and 4-43. Each system consists of a generator, generator control unit (GCU), bus contactor, and control switch. Control of the F-5F system is in the front cockpit only. Each generator is driven by an airframe-mounted accessory drive gearbox assembly which in turn is driven by shaft power from the respective engine.

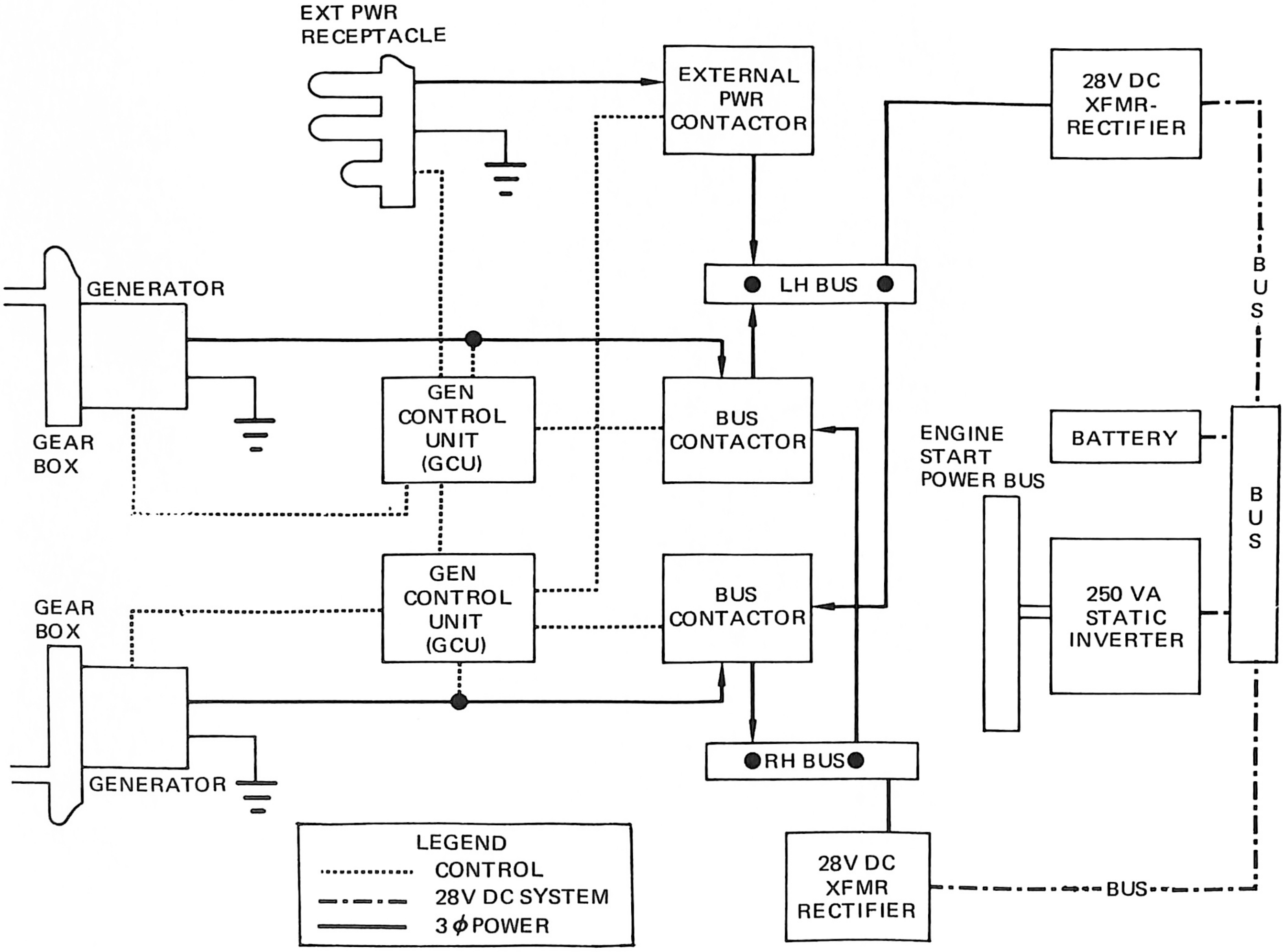

EXT PWR RECEPTACLE
EXTERNAL PWR CONTACTOR
28V DC XFMR-RECTIFIER
GENERATOR
GEAR BOX
LH BUS
BUS
GEN CONTROL UNIT (GCU)
BUS CONTACTOR
ENGINE START POWER BUS
BATTERY
BUS
250 VA STATIC INVERTER
GEAR BOX
GEN CONTROL UNIT (GCU)
BUS CONTACTOR
RH BUS
GENERATOR
LEGEND
CONTROL
28V DC SYSTEM
3φ POWER
28V DC XFMR RECTIFIER
BUS

FIGURE 4-42. F-5E/F ELECTRICAL SYSTEM BLOCK DIAGRAM

Each AC generator subsystem functions independently (nonparalleled) and provides approximately one-half of the total aircraft AC power requirements. The power output from each generator to its associated distribution bus is controlled by a bus contactor, operated from GCU signals. The GCU's and bus contactors provide automatic transfer of loads from an inoperative generator to the remaining generator, except under bus fault conditions in which case the GCU prevents transfer of the faulted bus to the other

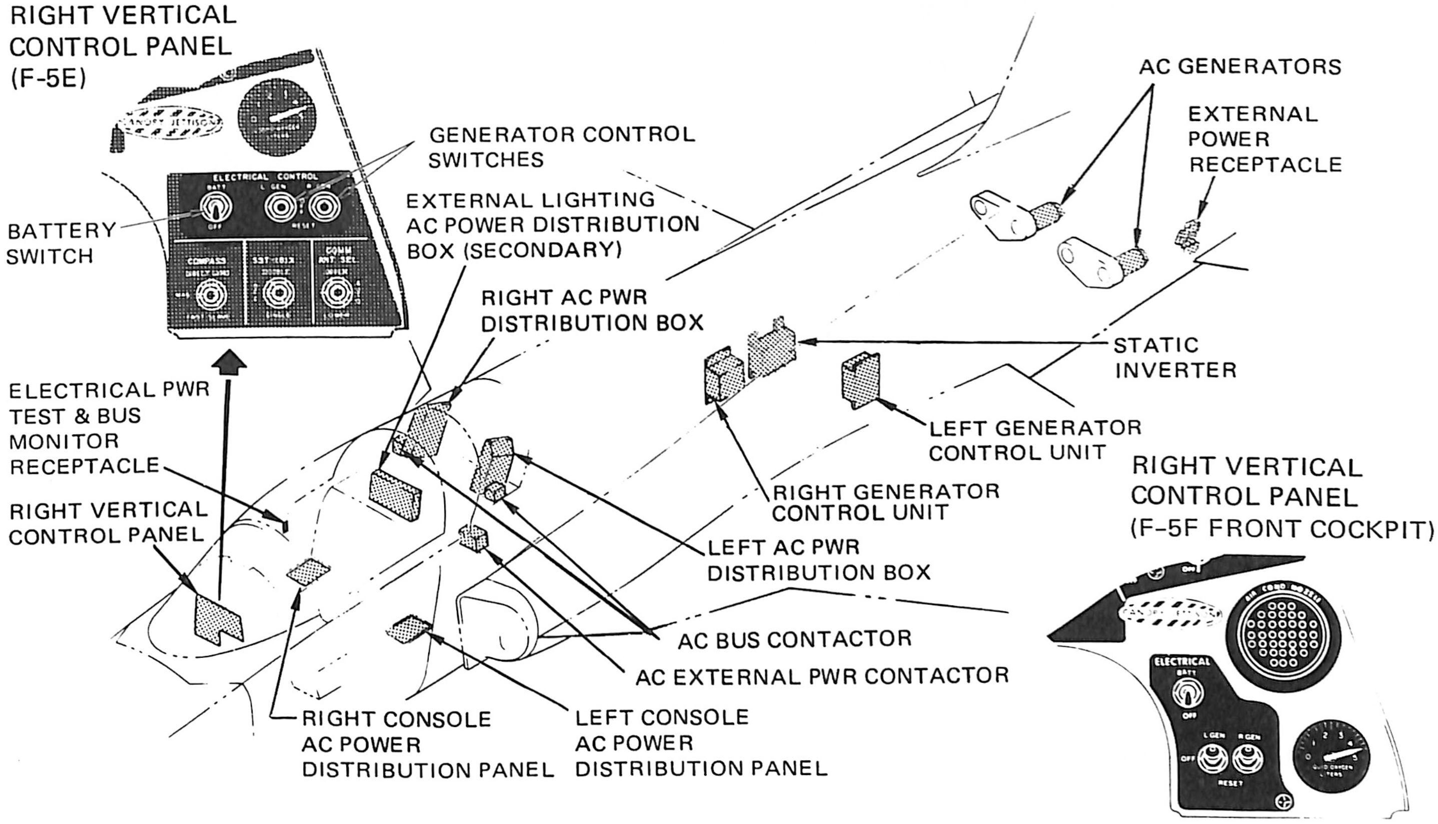

RIGHT VERTICAL CONTROL PANEL (F-5E)
BATTERY SWITCH
GENERATOR CONTROL SWITCHES
EXTERNAL LIGHTING AC POWER DISTRIBUTION BOX (SECONDARY)
RIGHT AC PWR DISTRIBUTION BOX
ELECTRICAL PWR TEST & BUS MONITOR RECEPTACLE
RIGHT VERTICAL CONTROL PANEL
AC GENERATORS
EXTERNAL POWER RECEPTACLE
STATIC INVERTER
LEFT GENERATOR CONTROL UNIT
RIGHT GENERATOR CONTROL UNIT
LEFT AC PWR DISTRIBUTION BOX
AC BUS CONTACTOR
AC EXTERNAL PWR CONTACTOR
RIGHT CONSOLE AC POWER DISTRIBUTION PANEL
LEFT CONSOLE AC POWER DISTRIBUTION PANEL
RIGHT VERTICAL CONTROL PANEL (F-5F FRONT COCKPIT)
ELECTRICAL CONTROL
ELECTRICAL
BATT
OFF
L GEN
R GEN
RESET

FIGURE 4-43. AC ELECTRICAL COMPONENTS

generator. An L GEN or R GEN OFF-RESET control switch for each generator is provided (front cockpit only in the F-5F), and a corresponding generator off warning indication is included on the caution light panel (both cockpits in the F-5F). Signals for indicator light operation are controlled by the respective subsystem bus contactors.

The generators are 13/15 kva, three-phase, 320/480 Hz, brushless aircooled and self-excited units which operate in the 6400 to 9600 rpm range. Generator frequencies vary with engine speed (rpm) from 320 Hz to 480 Hz above the 69-71 percent RPM shift band as shown in Figure 4-44. The generators are rated at 13 kva each from 320 to 380 Hz and 15 kva from 380 to 480 Hz. All missions can be executed at engine rpm's which result in generator frequencies between 380 and 480 Hz.

Each transistorized GCU consists of a voltage regulator and protective circuits. Under steady-state conditions between no load and full load the voltage regulator maintains set line voltage within ±2-1/2 percent. The protective circuits protect the AC generator system and aircraft equipment from damage due to overvoltage, undervoltage, overfrequency, underfrequency, and bus faults. These circuits also provide the generator system with anti-cycling control. The protection system uses average-phase voltage for overvoltage tripping and the lowest phase voltage for undervoltage tripping. The generator field circuit is deenergized when the overvoltage steady-state

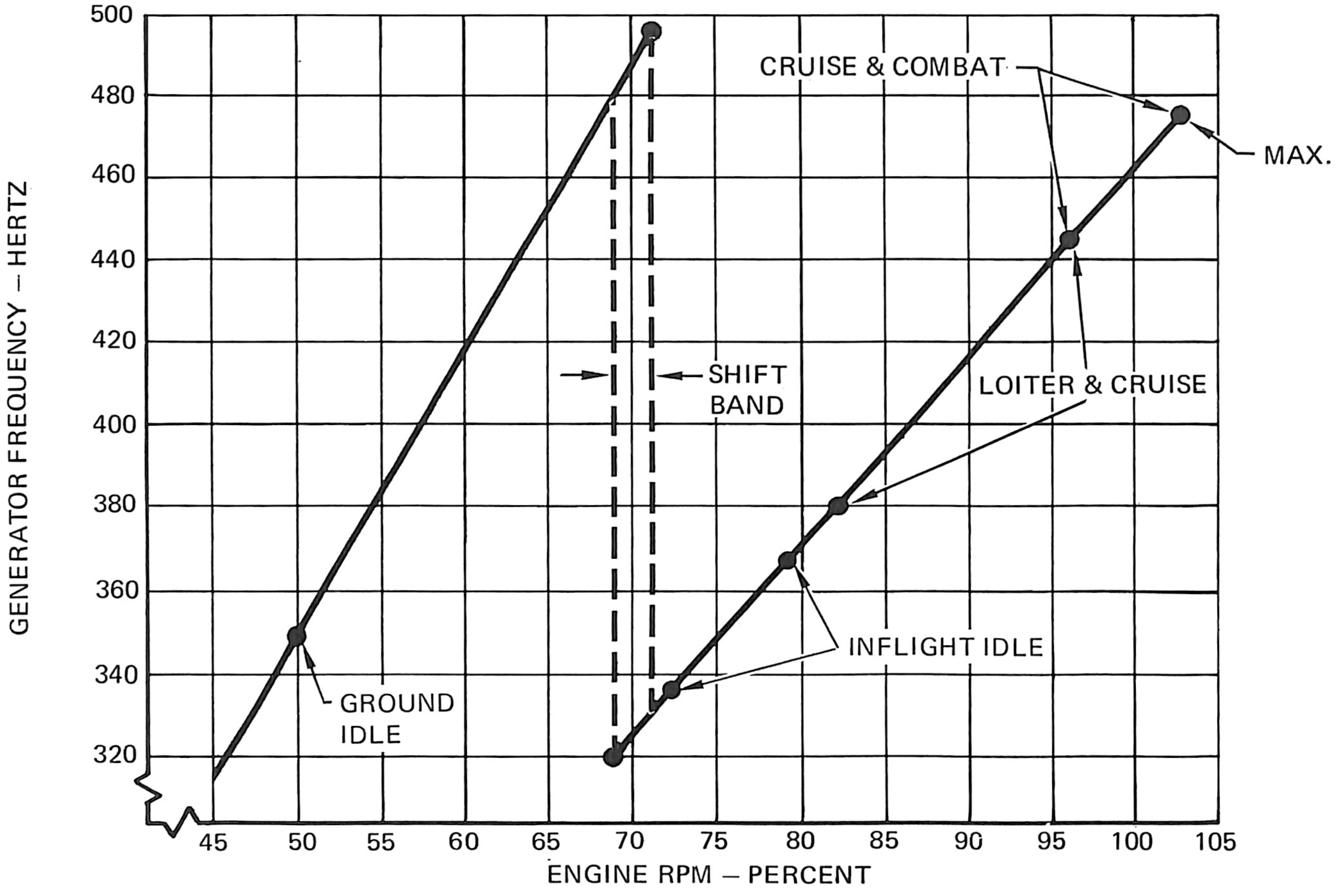


FIGURE 4-44. GENERATOR FREQUENCY VERSUS ENGINE RPM

is in excess of 124 volts line-to-neutral, or when the undervoltages are below 104 + 5, -0 volts line-to-neutral, for 2 to 3 seconds. If the output frequency exceeds 525 ±10 Hz for longer than 0.4 ±0.15 second, the overfrequency protective circuit deenergizes the generator field circuit. The underfrequency control removes the generator from the bus when the frequency remains at or below 305 ±5 Hz for longer than 0.4 ±0.15 second and connects the generator to the bus when increasing frequency is between 320 and 330 Hz. The control unit removes the generator from the line when a bus fault occurs, and prevents the faulted bus from being transferred to the other generator system.

Ground power can be applied to the left- and right-hand buses. The ground power unit energizes the system via the external power receptacle and phase-sequenced external power contactor to the left-hand AC bus, and via the bus transfer contactors to the right-hand AC bus. The generator GCU's provide the required controls and interlocks to automatically switch from ground to onboard power to preclude the simultaneous application of ground and onboard power to either main bus.

Secondary AC System. A 250 va, 115 volt, 400 Hz, single-phase solid-state static inverter is provided as a secondary AC power source. The inverter operates from the battery during on-ground engine starts (without external power applied) and inflight engine starts with both engines out. Input power to the inverter is initiated by the engine start circuit and maintained for approximately 40 seconds. The inverter output supplies left engine instrument power (during engine start sequence only) in addition to power for both engine ignitors. The inverter is also used for fuel/oxygen quantity checks.

### DC System

DC power is supplied by two 33-ampere, 26 to 32 volt transformer-rectifier (TR) units and a 24-volt, 11-ampere-hour, nickel-cadmium battery. DC system component locations in the F-5E aircraft are illustrated in Figure 4-45 and the inboard profile, Figure 4-1. The F-5F component location arrangement is slightly different as will be noted from Figure 4-2.

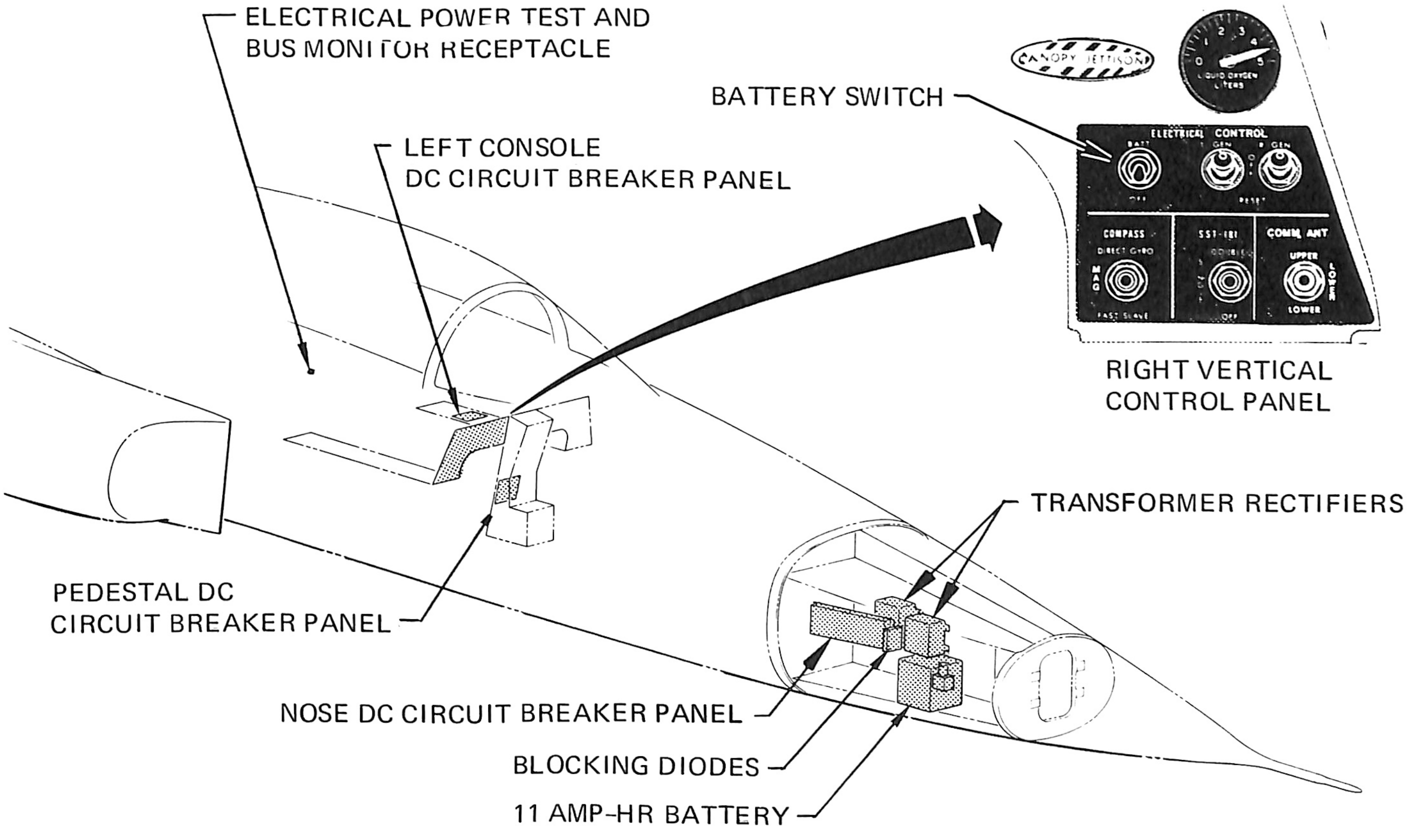

ELECTRICAL POWER TEST AND BUS MONITOR RECEPTACLE
BATTERY SWITCH
LEFT CONSOLE DC CIRCUIT BREAKER PANEL
CANOPY JETTISON
ELECTRICAL CONTROL
COMPASS
COMM ANT
UPPER
LOWER
RIGHT VERTICAL CONTROL PANEL
TRANSFORMER RECTIFIERS
PEDESTAL DC CIRCUIT BREAKER PANEL
NOSE DC CIRCUIT BREAKER PANEL
BLOCKING DIODES
11 AMP-HR BATTERY

FIGURE 4-45. F-5E DC ELECTRICAL COMPONENTS

Three-phase AC power input to one TR unit is supplied by the left-hand AC generator and to the other by the right-hand AC generator as shown schematically in Figure 4-42. TR DC outputs are connected in parallel to share all DC loads and provide battery charging. The battery is connected to the DC bus by a battery relay controlled by a switch in the cockpit.

In the F-5F only, there is a DC OVERLOAD light in the caution light panel. The signal for the light is provided from an overload detector which senses the output current of each TR unit by means of magnetic amplifier circuitry. The TR output wires are routed through a pair of toroids in the detector assembly. The caution light will come on when either TR unit becomes overloaded and will remain on until the overload condition is decreased to 31 amps or less.

## ENVIRONMENTAL CONTROL SYSTEMS

### Cabin Conditioning System

The F-5E cabin conditioning system provides ventilation, heating, cooling, moisture control, defogging and cabin pressurization by appropriate control of air temperature and pressure in the cabin. Compressor bleed-air from each engine is used as the temperature and pressure control agent. The system is capable of providing a cabin environment of 40° to 100°F depending on selector setting, engine RPM and outside ambient conditions.

The F-5E cabin conditioning system consists of a conditioning unit, temperature control system, water separator, cabin pressure regulator, shutoff valve, cabin ram-air valve, safety valve and ducting. The system components are shown in Figure 4-46. The conditioning unit is made up of a simple air-cycle turbine-fan assembly and heat exchanger. The temperature control system consists of a flow control valve and motor, duct-air temperature sensor, cabin-air temperature sensor, electronic controller, cabin temperature selector, cabin conditioning pressurization switch, and cabin temperature manual or automatic control switch. The water separator consists of a coalescer section, a collector-separator section and a relief valve. The F-5E cabin conditioning system is shown schematically in Figure 4-47.

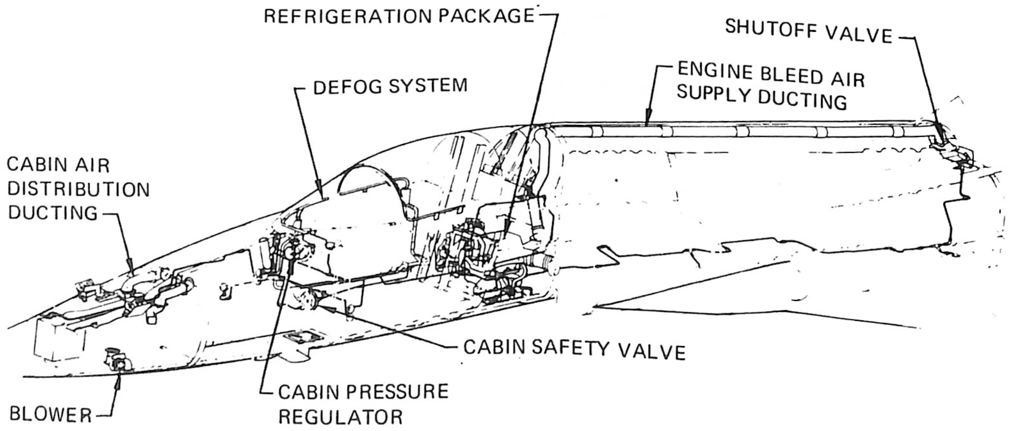


FIGURE 4-46. F-5E CABIN CONDITIONING SYSTEM

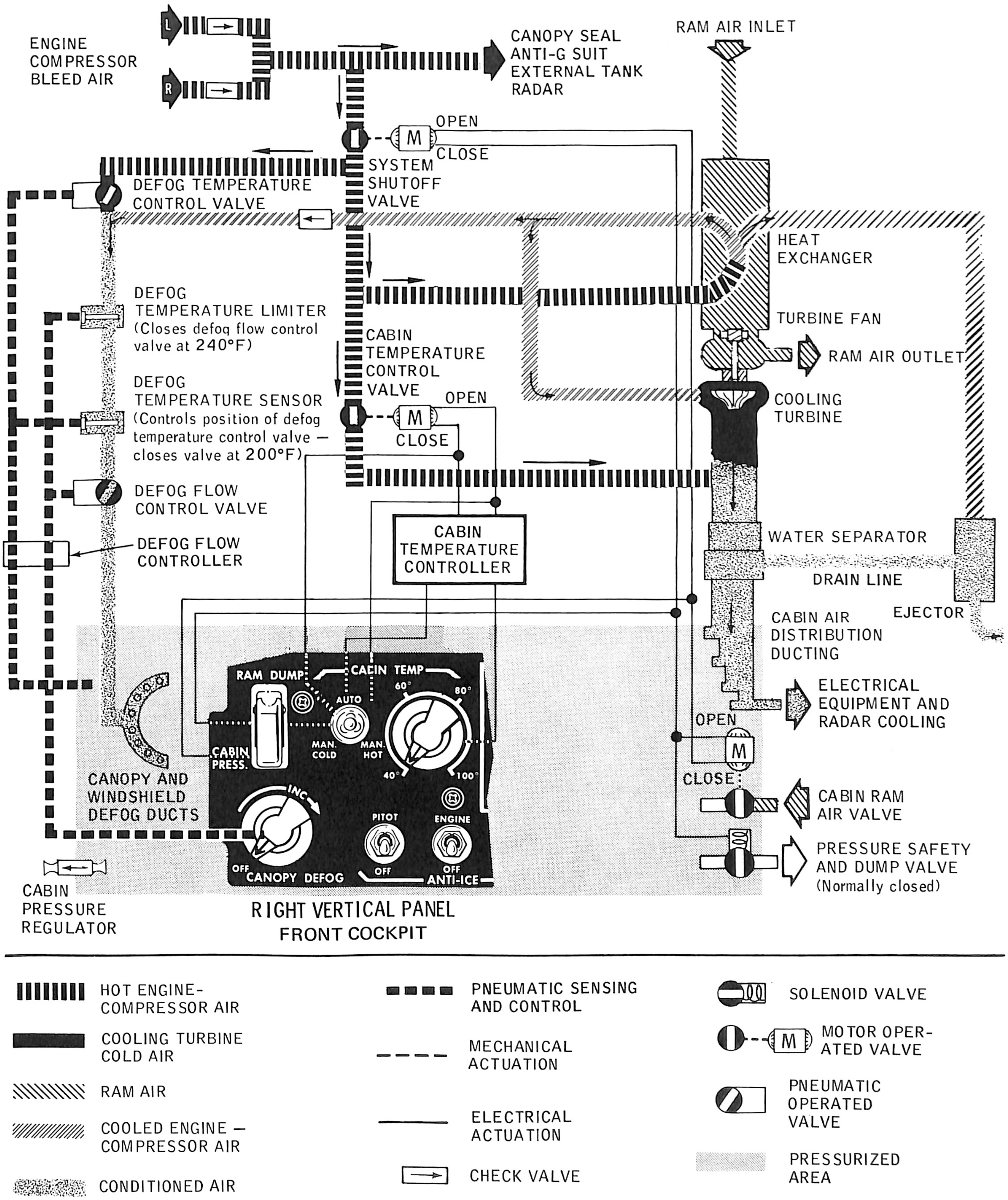

ENGINE COMPRESSOR BLEED AIR
L
R
CANOPY SEAL
ANTI-G SUIT
EXTERNAL TANK
RADAR
RAM AIR INLET
OPEN
M
CLOSE
SYSTEM SHUTOFF VALVE
DEFOG TEMPERATURE CONTROL VALVE
HEAT EXCHANGER
DEFOG TEMPERATURE LIMITER (Closes defog flow control valve at 240°F)
CABIN TEMPERATURE CONTROL VALVE
TURBINE FAN
RAM AIR OUTLET
DEFOG TEMPERATURE SENSOR (Controls position of defog temperature control valve — closes valve at 200°F)
OPEN
M
CLOSE
COOLING TURBINE
DEFOG FLOW CONTROL VALVE
CABIN TEMPERATURE CONTROLLER
DEFOG FLOW CONTROLLER
WATER SEPARATOR
DRAIN LINE
EJECTOR
CABIN AIR DISTRIBUTION DUCTING
RAM DUMP
CABIN TEMP
AUTO
60°
80°
CABIN PRESS.
MAN. COLD
MAN. HOT
40°
100°
INC
PITOT
ENGINE
OFF
OFF
OFF
CANOPY DEFOG
ANTI-ICE
ELECTRICAL EQUIPMENT AND RADAR COOLING
OPEN
M
CLOSE
CANOPY AND WINDSHIELD DEFOG DUCTS
CABIN RAM AIR VALVE
PRESSURE SAFETY AND DUMP VALVE (Normally closed)
CABIN PRESSURE REGULATOR
RIGHT VERTICAL PANEL
FRONT COCKPIT
HOT ENGINE-COMPRESSOR AIR
COOLING TURBINE COLD AIR
RAM AIR
COOLED ENGINE — COMPRESSOR AIR
CONDITIONED AIR
PNEUMATIC SENSING AND CONTROL
MECHANICAL ACTUATION
ELECTRICAL ACTUATION
CHECK VALVE
SOLENOID VALVE
M
MOTOR OPERATED VALVE
PNEUMATIC OPERATED VALVE
PRESSURIZED AREA

FIGURE 4-47. F-5E CABIN AIR CONDITIONING AND PRESSURIZATION SYSTEM

The F-5F cabin conditioning system is functionally equivalent to the F-5E system and the inlet parameters are the same. The cooling capability, however, has been increased to meet MIL-E-38453 cabin temperature requirements. The system contains most of the same elements as the F-5E system with the principal difference occurring in the refrigeration package. The F-5F package contains a dual-temperature control valve and a turbine pressure regulating valve which keep the air flow more constant over the range of output temperature selection. In addition the three valves are closed completely when the DEFOG ONLY mode is selected making it possible to operate the canopy windshield defog system without the cabin conditioning function. A new heat exchanger with fan bypass provisions is also incorporated. The cabin environment is controlled by the CABIN PRESS switch on the right vertical console (front cockpit only) as shown in Figure 4-48. This switch has three positions: DEFOG ONLY, NORMAL, and RAM DUMP. The NORMAL position allows full use of cabin temperature control, canopy-windshield defog and cabin pressurization. DEFOG ONLY position allows only the use of the defog system. The RAM DUMP position closes the system shutoff valve, opens the cabin safety valve and opens the ram air valves. A schematic of the system is shown in Figure 4-48.

Cabin Air Temperature Control. Cabin air temperature is controlled by mixing the turbine-discharge airflow from the conditioning unit with compressor bleed air from the engines. When the system shutoff valve is in the open position, compressor bleed air enters the system supply ducting and flows through the hot side of the heat exchanger, where the temperature is reduced by ram air flowing through the cooling side. After leaving the heat exchanger, the bleed air passes through the conditioning unit turbine which further reduces the temperature.

The turbine discharge airflow is then mixed with engine compressor bleed-air flow (which has bypassed the turbine and heat exchanger) in the proper proportion to maintain the required cabin air temperature. Ram air enters the heat exchanger where it acts as a coolant for the engine bleed air. Ram air then enters the fan from the heat exchanger, where it is exhausted overboard from the exhaust duct through the lower fuselage. The fan circuit assures a continuous supply of ram air to the heat exchanger, even when sufficient ram air pressure is not available as a driving force to pump air through the heat exchanger cooling circuit. The system provides automatic and manual temperature control.

On the F-5E, after the airflows are mixed to the proper temperature, the air passes through the water separator where a large percentage of the entrained moisture is removed before it is ducted to the cabin. The removed moisture is dumped overboard through a drain line from the collector section of the water separator. On the

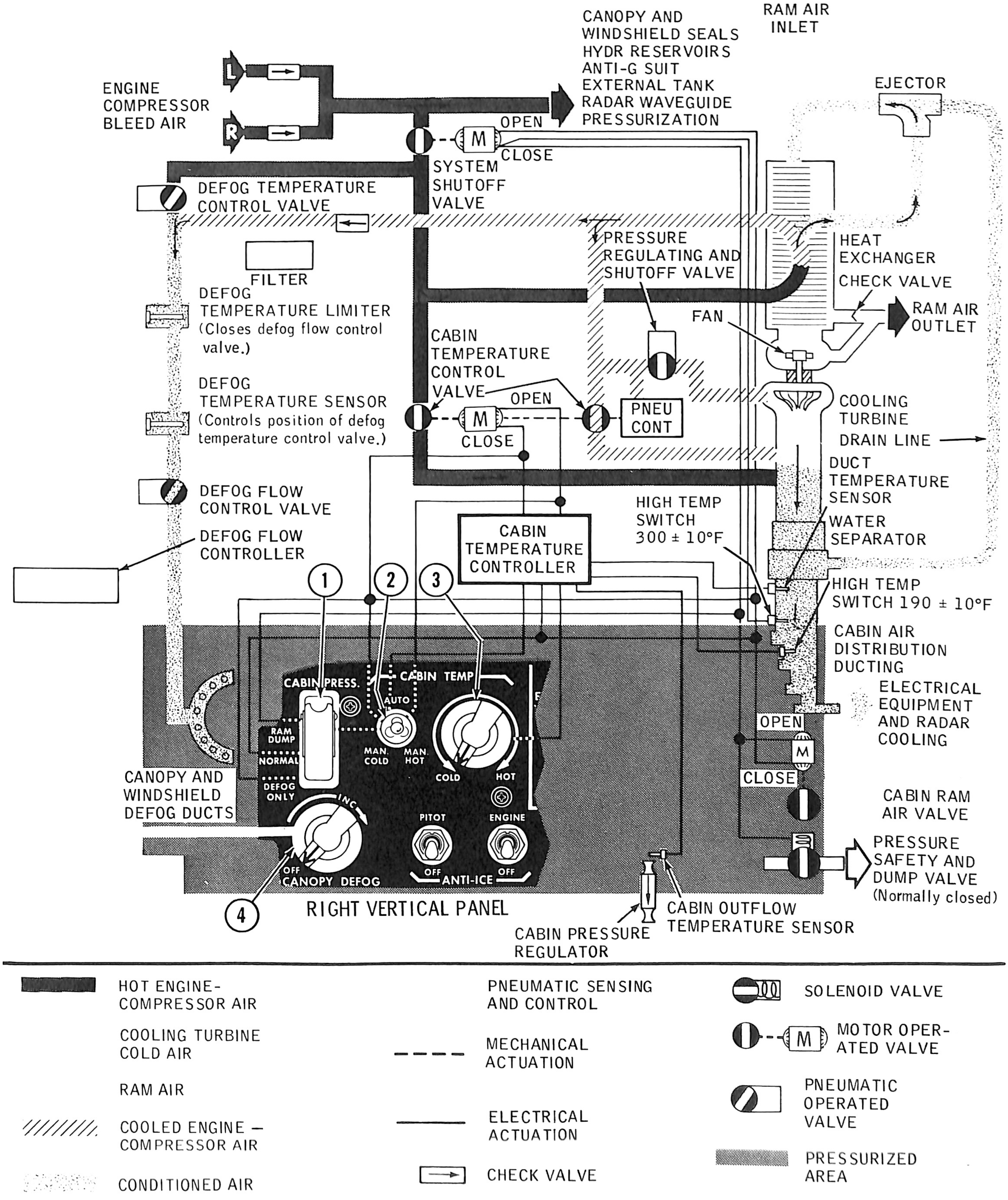

CANOPY AND WINDSHIELD SEALS
HYDR RESERVOIRS
ANTI-G SUIT
EXTERNAL TANK
RADAR WAVEGUIDE
PRESSURIZATION
RAM AIR INLET
ENGINE COMPRESSOR BLEED AIR
L
R
OPEN
M
CLOSE
SYSTEM SHUTOFF VALVE
EJECTOR
DEFOG TEMPERATURE CONTROL VALVE
FILTER
DEFOG TEMPERATURE LIMITER (Closes defog flow control valve.)
PRESSURE REGULATING AND SHUTOFF VALVE
HEAT EXCHANGER
CHECK VALVE
RAM AIR OUTLET
FAN
CABIN TEMPERATURE CONTROL VALVE
OPEN
M
CLOSE
PNEU CONT
DEFOG TEMPERATURE SENSOR (Controls position of defog temperature control valve.)
COOLING TURBINE
DRAIN LINE
DUCT TEMPERATURE SENSOR
DEFOG FLOW CONTROL VALVE
HIGH TEMP SWITCH 300 ± 10°F
WATER SEPARATOR
DEFOG FLOW CONTROLLER
CABIN TEMPERATURE CONTROLLER
①
②
③
HIGH TEMP SWITCH 190 ± 10°F
CABIN AIR DISTRIBUTION DUCTING
CABIN PRESS.
CABIN TEMP
AUTO
RAM DUMP
NORMAL
DEFOG ONLY
MAN. COLD
MAN. HOT
COLD
HOT
ELECTRICAL EQUIPMENT AND RADAR COOLING
OPEN
M
CLOSE
CANOPY AND WINDSHIELD DEFOG DUCTS
INC
PITOT
ENGINE
OFF
OFF
OFF
CANOPY DEFOG
ANTI-ICE
CABIN RAM AIR VALVE
PRESSURE SAFETY AND DUMP VALVE (Normally closed)
④
RIGHT VERTICAL PANEL
CABIN OUTFLOW TEMPERATURE SENSOR
CABIN PRESSURE REGULATOR
HOT ENGINE-COMPRESSOR AIR
COOLING TURBINE COLD AIR
RAM AIR
COOLED ENGINE – COMPRESSOR AIR
CONDITIONED AIR
PNEUMATIC SENSING AND CONTROL
MECHANICAL ACTUATION
ELECTRICAL ACTUATION
CHECK VALVE
SOLENOID VALVE
MOTOR OPERATED VALVE
PNEUMATIC OPERATED VALVE
PRESSURIZED AREA

FIGURE 4-48. F-5F CABIN AIR CONDITIONING AND PRESSURIZATION SYSTEM

F-5F, it is dumped into the inlet ram air circuit where it evaporates, thereby decreasing the cooling load.

On the F-5F, in the AUTO mode the temperature in the cockpit is controlled between 50° and 150°F. However an override circuit precludes air exhausting from the cockpit from exceeding 105°F. In the manual mode of operation there is no lower limit of operation. Anti-icing is accomplished by back-pressuring the turbine. A high limit cutout of 190°F is provided. In the event of a malfunction of both the auto and manual modes of operation a system shutoff switch set at 300°F closes the main system shutoff valve. This switch must be reset upon the ground by the maintenance crew.

Cabin Ram-Air Ventilation. During periods when the conditioning unit is inoperable or when its operation is not desired, the cabin is ventilated by a ram-air system, and temperature control is not available. Movement of the cabin conditioning switch to the RAM DUMP position results in the system shutoff valve closing, and the cabin ram-air valve and cabin safety valves opening. This action shuts off bleed air to the conditioning unit, stopping its operation; ram air is then supplied to the cabin through the ram-air valve and discharged through the safety valve. The canopy seal, anti-g suit system and fuel pressurization system are still activated when the switch is in the RAM DUMP position.

Cabin Air Pressure Control. Cabin air is automatically controlled by a pressure regulator which consists of an outflow valve to restrict the discharge airflow and a regulator control unit to position the valve to a predetermined schedule. Cabin pressure is maintained at ambient conditions from sea level to 8000 feet, and at 8000 feet ±1000 feet from 8000 feet up to an altitude of 23, 500 feet. Cabin pressure is maintained at 5 psi above ambient static, from 23, 500 feet to the operational ceiling of the aircraft.

Canopy and Windshield Defogging System. Defog airflow to the canopy is controlled by the pilot. This is accomplished by rotating the defog selector located on the right-hand panel. The defogging system prevents moisture condensation on the windshield and canopy. Defog airflow is supplied from the cabin conditioning unit and main engine bleed. Engine compressor bleed-air is mixed with conditioning unit heat-exchanger discharge air to obtain a mixed airflow temperature of 200°F. In the event of a malfunction, the system limits the defogging air temperature to a maximum of 280°F. Pressure in the F-5E defog duct is regulated to 18±2 psi above the cabin pressure. In the F-5F, the defog duct pressure is regulated to 25±2 psi above cabin pressure.

## Equipment Bay Conditioning System

A duct system distributes air throughout the forward avionics compartment in the nose, to maintain a proper temperature range for the electronic equipment during ground maintenance, taxiing, and flight. Air is normally exhausted from the cabin through the cabin pressure regulator into the forward compartment during flight. In the F-5E, ram air from the cockpit provides cooling when the conditioning system is in the RAM DUMP position. In the F-5F, air is provided by the nose ram air system when the cabin is operating in the RAM DUMP and DEFOG ONLY modes. Two motor-driven blowers are mounted in the forward fuselage to provide proper ground cooling. When the weight of the airplane is on the landing gear, both blower doors open and both blowers operate to introduce outside air into the compartment.

The electrical equipment compartment located behind the cockpit, is part of the pressurized cockpit area. The upper surface of the cabin conditioning unit compartment forms the floor of this compartment. Cooling airflow to the aft compartment is supplied by the refrigeration package during flight. During ground operation, cooling airflow to this compartment is supplied by convection.

## Gun Bay Purging System

Purging of gun gas from the gun bay is accomplished by circulating ram air through each gun compartment as shown in Figure 4-49. Each gun has an independent purge system linked to its firing circuits. Purging begins prior to gun firing and operates for ten seconds after firing to ensure complete displacement of gun gas from the compartments. Gun bay purging operates in an identical manner in the F-5F except that it serves only one gun.

A hydraulically-actuated deflector assembly is provided on the aircraft nose forward of each gun muzzle, to divert gun gas away from the engine inlets. The deflectors are flush when retracted. The intake and exhaust purge doors and the gun gas deflector doors are actuated automatically by the trigger, and they open before gun firing commences. If the purge or gas deflector doors fail to open and lock, a microswitch de-energizes the gun-firing circuit of the respective gun.

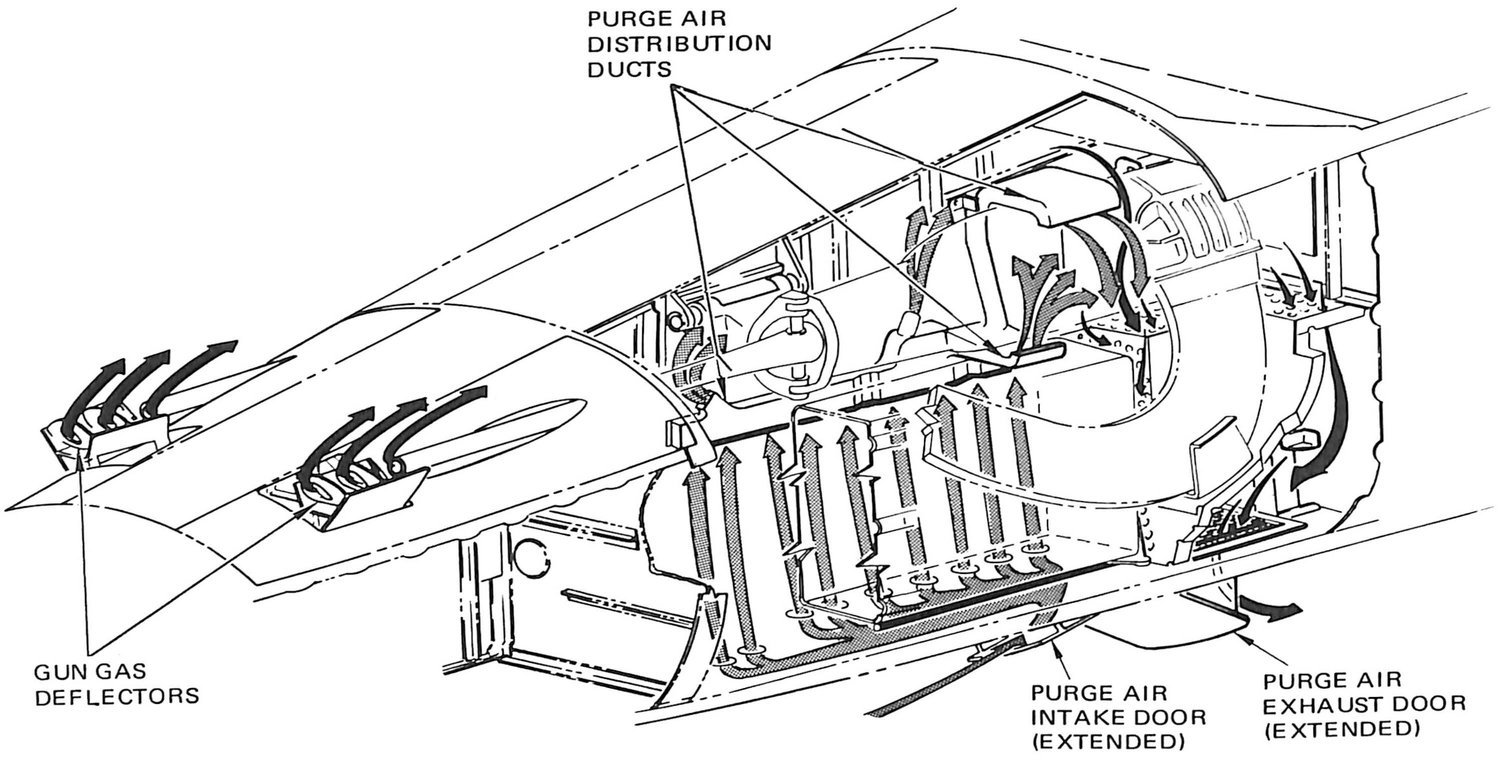

PURGE AIR DISTRIBUTION DUCTS
GUN GAS DEFLECTORS
PURGE AIR INTAKE DOOR (EXTENDED)
PURGE AIR EXHAUST DOOR (EXTENDED)

FIGURE 4-49. F-5E GUN BAY PURGING SYSTEM

### Rain Repellent System

The rain repellent system, used only on the F-5E, is designed to provide adequate pilot vision through the windshield in rain. The system consists of a repellent fluid supplied in throwaway-type nitrogen-pressurized aerosol containers, a container receptacle (manifold), a solenoid valve, timer, pressure gauge, and connecting plumbing to a delivery manifold with multiple nozzles, as shown in Figure 4-50.

The rain repellent fluid container is located in the nose section plenum chamber directly forward of the windshield. Access to the container for replacement is accomplished through a door located in front of the windshield. The pressure gauge is located in the nosewheel well where it can be inspected without having to remove an access door.

Repellent fluid flow is actuated by a switch in the F-5E cockpit and controlled by a solenoid valve. An electrical timing circuit energizes the solenoid for 0.4 second when the cockpit button is pressed, and the nozzle directs the fluid to the base of the windshield. As fluid flows over the windshield, the solvent evaporates, leaving the concentrated repellent agent to react with the rain and disperse over the windshield as a transparent water-repellent film. One application normally lasts ten minutes or longer, although the effective time is determined by rain intensity, aircraft speed, and windshield surface condition. The container will provide approximately 50 applications before replacement is required.

The F-5F has no on-board rain removal system. The airplane will utilize an Air Force-developed rain repellant system called "Total Finish." This is a solution that is hand-applied to the windshield by the crew chief during ground maintenance of the aircraft. The method is defined by Air Force T.O.

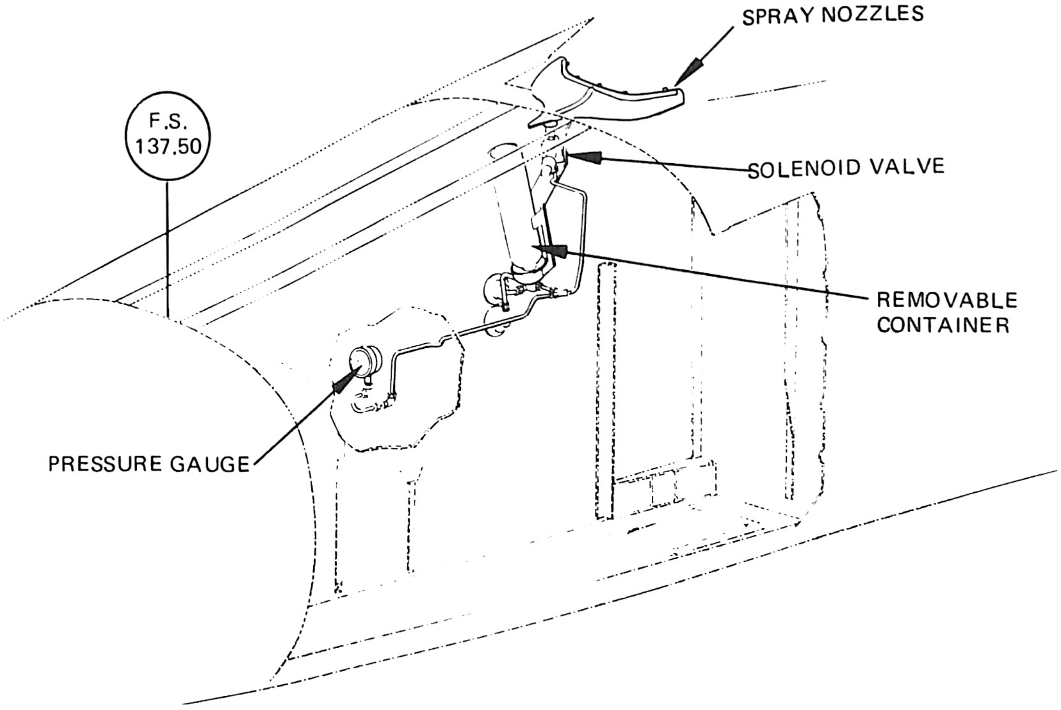
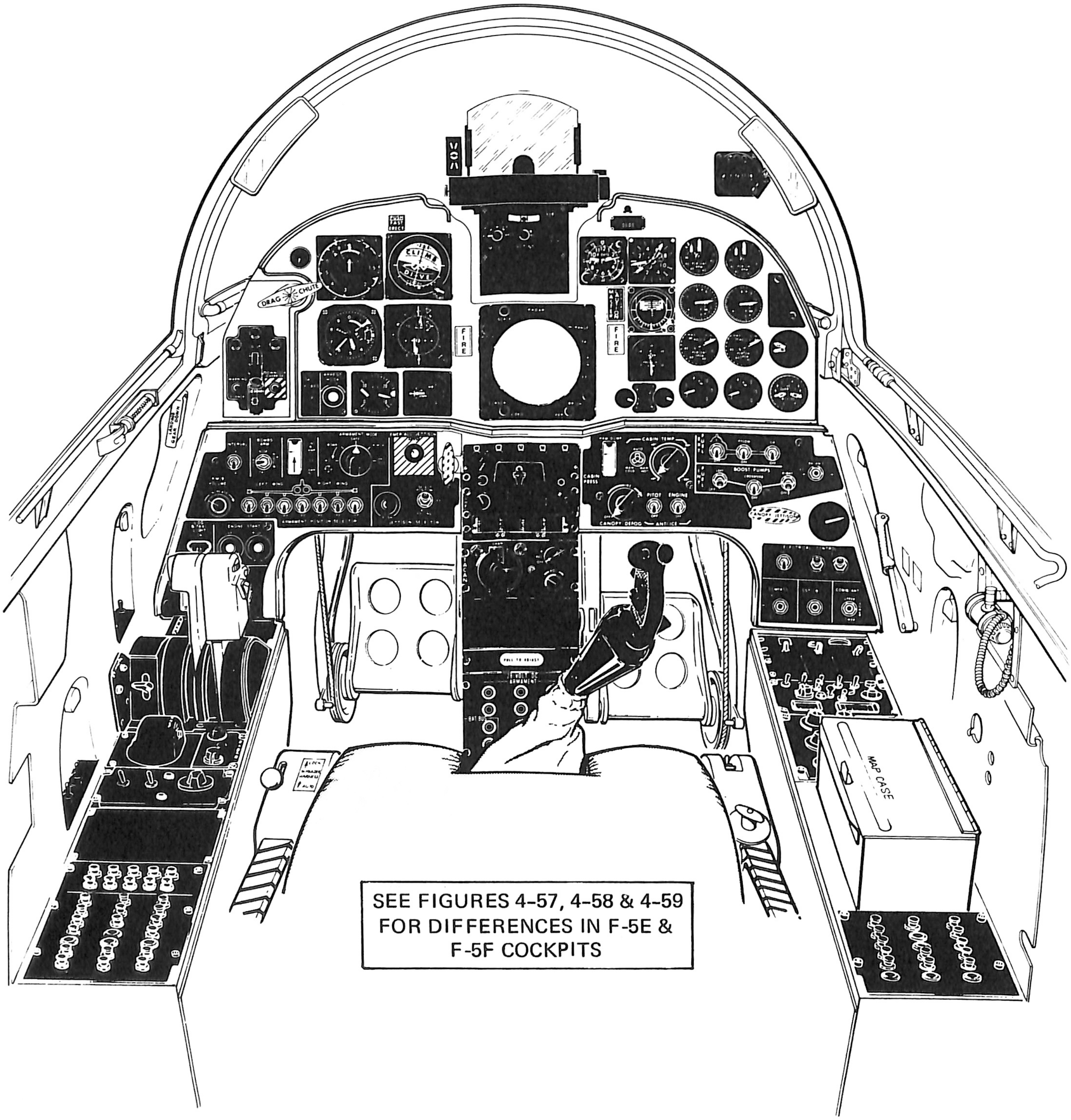


FIGURE 4-50. F-5E RAIN REPELLENT SYSTEM

## CREW STATION

The arrangement of the F-5E crew station is shown in Figure 4-51. Basic aircraft controls and all fixed cockpit substructure and equipment are correlated with pilot position and capabilities. Optimum compatibility between the pilot and his working environment is insured in this arrangement. The location of all primary equipment such as flight controls, aircraft system controls, ejection seat, and console structure provides considerable flexibility for accommodating different subsystem configurations.


DRAG CHUTE
CLIMB
DIVE
FIRE
FIRE
CABIN TEMP
BOOST PUMPS
PITOT
ENGINE
CANOPY DEFOG
ANTI ICE
MAP CASE

SEE FIGURES 4-57, 4-58 & 4-59 FOR DIFFERENCES IN F-5E & F-5F COCKPITS

FIGURE 4-51. F-5E CREW STATION ARRANGEMENT

## Cockpit Enclosure

Windshield and Canopy. The cockpit is enclosed by the windshield and canopy assemblies. The windshield assembly has a slope of 24 degrees on the F-5E and 27.5 degrees on the F-5F. It is hinged at the forward end to provide access to the forward side of the instrument panel. The rear cockpit on the F-5F also has a windshield, mounted inside the pressurized area. The canopies open up and aft to provide easy cockpit entry and egress. Each cockpit on the F-5F is covered by a separate canopy assembly. The canopies are raised and lowered by hand pressure applied to the forward canopy frame. They are hinged and spring counterbalanced by an all-mechanical system which consists of a four-bar hinge mechanism, latching and locking devices and linkage as shown in Figure 4-52. The locking system employing over-center devices can be actuated by either an internal or external handle. A CANOPY unlock caution light is provided in the caution light panel.

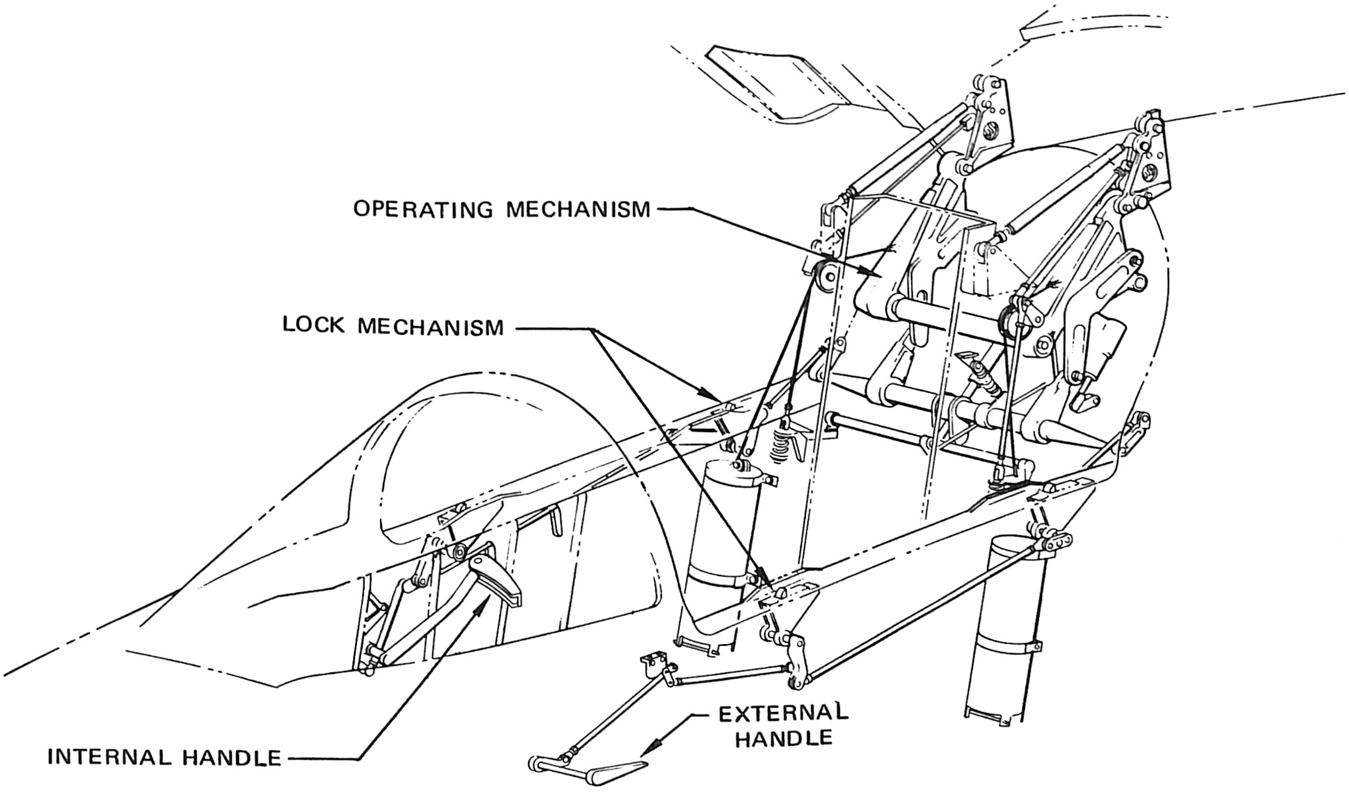


FIGURE 4-52. CANOPY HINGE MECHANISM

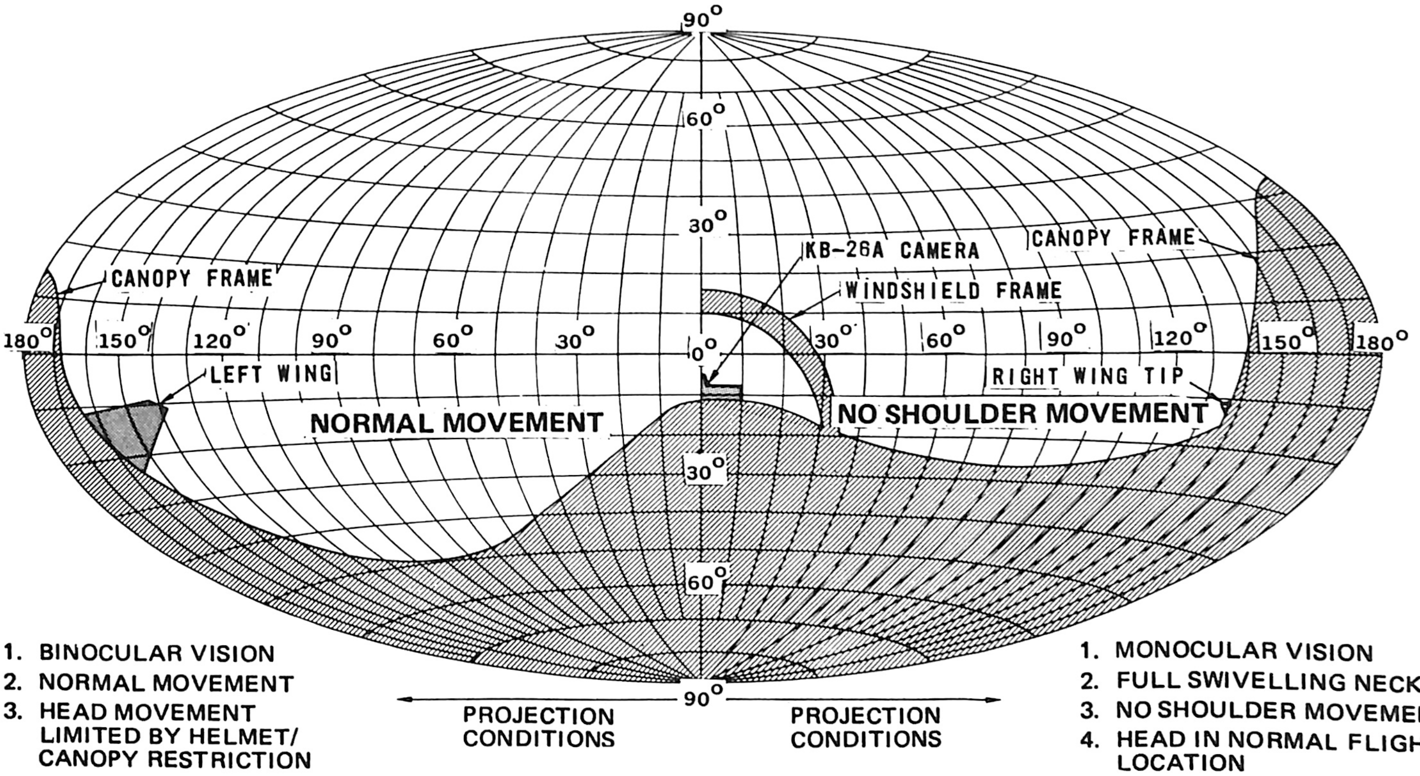
A damper mounted in the hinge mechanism controls canopy opening or closing rates. The canopy disengages at the latch-disconnect points when the damper mechanism is subjected to an overload. The canopy can be jettisoned by manually releasing the locks or by actuating a ballistic thruster that is initiated internally by a T-handle or levers on the seat arm-rests or externally (ground rescue) by a D-handle. Any of these jettison methods separates the canopy at the two latch-disconnect points.

Canopy and Windshield Seal System. The F-5E/F canopies and windshield are sealed to the aircraft structure by inflatable rubber seals. The seals are inflated with air supplied from the ninth stage of each engine compressor. Air routed to the canopy seal pressure regulator is controlled by a limit switch which deenergizes the regulator solenoid, permitting the seals to inflate and maintain a cockpit pressure of 15 psi. When the canopies are open (or unlocked) the regulator solenoid energizes and the seals are deflated.

Visibility. Pilot vision from the F-5E cockpit is the same as that from the F-5A (except for slightly improved visibility past the wingtips). It is considered to be a good balance of over-nose vision versus instrument panel height, over-side vision versus cockpit rail spacing, and aft vision versus low-drag dorsal fairing. The single generous radius frame of the windshield/canopy combination (refer to Figures 4-51 and 4-54) has resulted in many favorable pilot comments regarding the feeling of unobstructed forward visibility. F-5E forward vision is enhanced during takeoff and landing in rain by use of the windshield rain repellent system. Total vision from the F-5A cockpit has been rated excellent by USAF pilots who have flown the F-5A in air-to-air combat maneuvers and air-to-ground attack competitions.

A plot of the F-5E cockpit visibility is shown in Figure 4-53. This plot shows that the minimum straight ahead over-the-nose vision is 11 degrees down from eye level, and the visibility aft is in excess of 165 degrees at eye level with normal shoulder movement. With no shoulder movement the aft eye level visibility is still almost 140 degrees.

Visibility from the front cockpit of the F-5F is similar to that of the F-5E. Some differences exist because of the more forward location of the front cockpit and the slightly different nose shape but, overall, the experienced F-5E pilot will notice only slight differences in visibility in the front cockpit of the F-5F. Visibility from the rear cockpit of the F-5F is better than the rear cockpit visibility in any other current two-seat high-performance fighter. The rear seat pilot is located an average of 10 inches above the front seat pilot, depending on seat adjustments and pilot stature, and thus has a 5° down over-the-nose vision looking directly over the front pilot. The visibility from the rear cockpit is such that the second pair of eyes can make a definite contribution in air combat as well as allowing the instructor pilot to fly takeoffs, approaches and landings when required. The F-5F cockpit design draws heavily on the design and experience gained with the F-5B and T-38. The rear cockpit visibility for these airplanes is rated as excellent by experienced instructor pilots.


90°
60°
30°
KB-26A CAMERA
CANOPY FRAME
WINDSHIELD FRAME
CANOPY FRAME
180°
150°
120°
90°
60°
30°
0°
30°
60°
90°
120°
150°
180°
LEFT WING
RIGHT WING TIP
NORMAL MOVEMENT
NO SHOULDER MOVEMENT
30°
60°
90°
PROJECTION CONDITIONS
PROJECTION CONDITIONS

1. BINOCULAR VISION
2. NORMAL MOVEMENT
3. HEAD MOVEMENT LIMITED BY HELMET/ CANOPY RESTRICTION

1. MONOCULAR VISION
2. FULL SWIVELLING NECK
3. NO SHOULDER MOVEMENT
4. HEAD IN NORMAL FLIGHT LOCATION

**FIGURE 4-53. F-5E COCKPIT VISIBILITY**

### Escape System

The F-5E/F escape systems are fully automatic and provide survival capability at aircraft speeds from 120 knots at ground level to 600 knots at altitude. On the F-5F the front and aft escape systems are identical, operate independently and are not sequenced. The Northrop designed ejection seat* is powered by a rocket catapult. Dual initiation systems are incorporated in the seat controls. Raising the left or right legbrace handgrip and pulling the trigger locks the shoulder harness inertia reel, jettisons the canopy, and fires the seat-ejection catapult. The seat is also equipped with a canopy piercer to enable ejection through the canopy in the event it fails to jettison. A ballistic rotary actuator provides positive seat/man separation after ejection. The seat also incorporates space for a global survival kit.

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*A description of the optional improved Northrop ejection seat is presented in Appendix A.

Following is a list of the standard F-5E/F personal equipment/ejection seat interface items. All are GFAE and are identified by USAF type number.

Parachute BA-22, BA-18
Lap Belt HBU-2B/A
Helmet HGU-2A/P
Oxygen Mask MBU-5/P
Anti-G Suit CSU-12, CSU-3/P
Coveralls K-2B
Survival Vest SRU-21/P
Boots FWU-8P
Shoulder Harness MB-6
Survival Kit CNU-68B/P
Lowering Device (Parachute) PCU-10/P (for descent from a parachute hung up in a tall tree or equivalent)

Canopy Jettison System. Canopy jettison may be initiated by any of four separate means: ejection seat initiators, canopy jettison initiators actuated by a canopy jettison T-handle, the normal canopy control lever which is effective at speeds above 60 KIAS, and an initiator actuated by the external emergency control D-handle. The canopy and canopy jettison controls are illustrated in Figure 4-54.

Ejection Seat. The F-5E/F ejection seat shown in Figure 4-55 is mounted on tracks attached to the aircraft structure and is supported by a connection between the catapult and seat-adjustment unit. Six slide blocks are installed on the back of the ejection seat to keep it positioned between the tracks and to permit the seat to slide upward and out of the airplane during ejection. The seat incorporates a canopy piercer at the top and will eject through the canopy should the canopy jettison system malfunction. The seat equipment includes an M-38 ejection rocket catapult, calfguard, two legbraces, ground safety pin, two catapult firing triggers, seat-adjustment unit and toggle switch, shoulder harness inertia reel and locking lever, automatic lap-belt release, headrest, seat-type global survival kit, seat/man separator system, and five cartridge initiators.

The M-38 rocket catapult provides higher average seat-rail separation velocity than the M-9 catapult used in the F-5A: 45 feet/second versus 35 feet/second for the M-9. This increase provides additional tail clearance margin and higher overall ejection trajectories. The M-38 catapult also incorporates a rocket nozzle stop which is

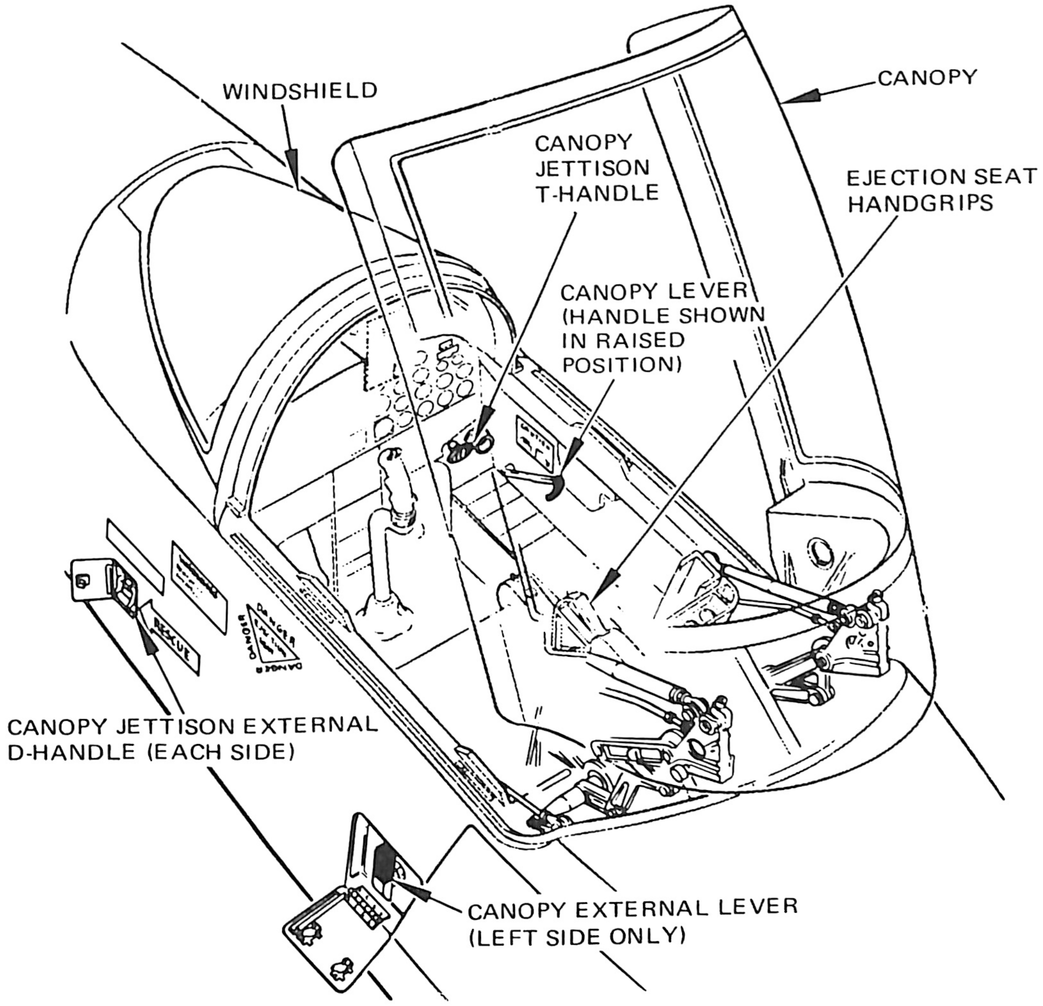
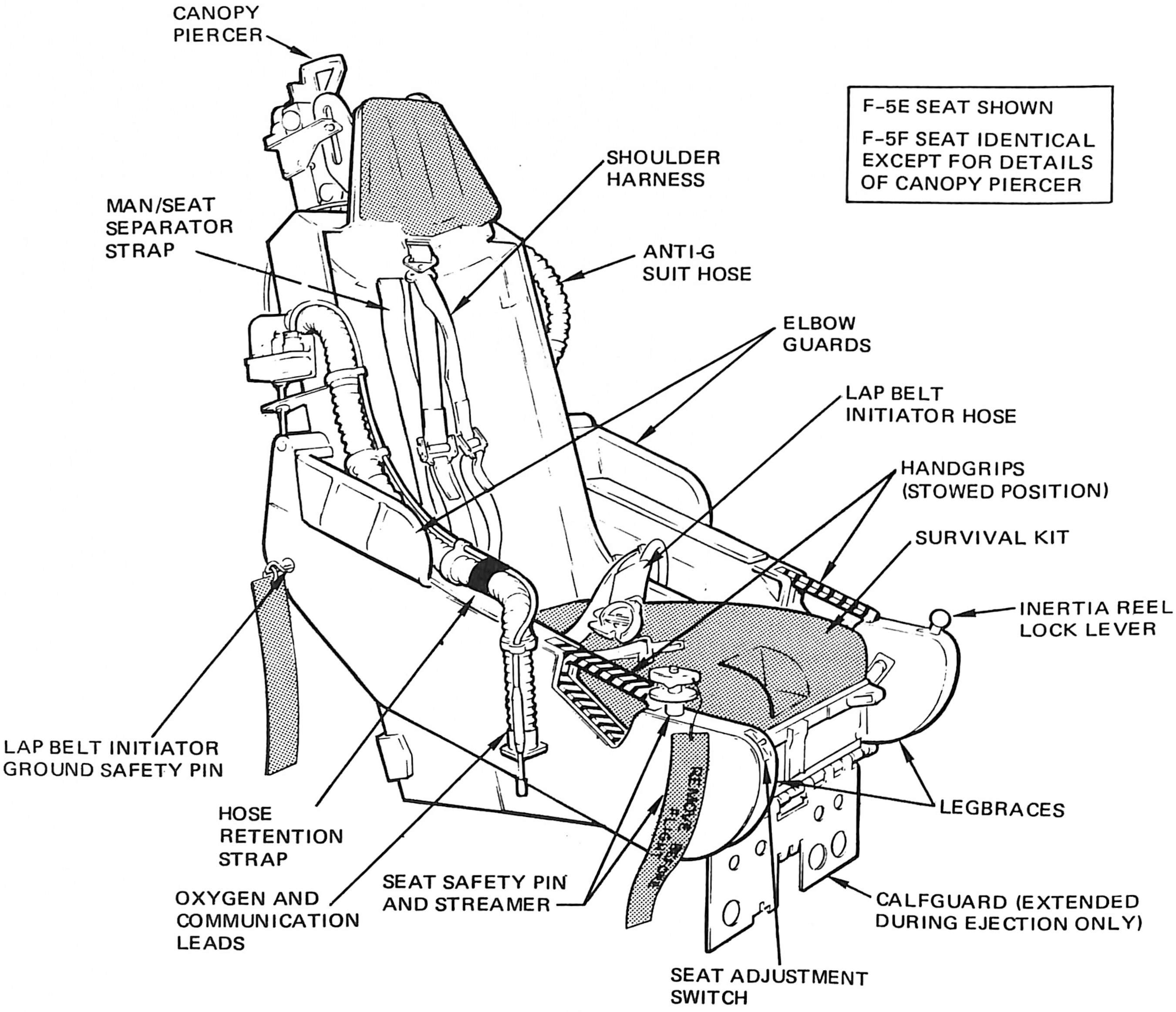

WINDSHIELD
CANOPY
CANOPY JETTISON T-HANDLE
EJECTION SEAT HANDGRIPS
CANOPY LEVER (HANDLE SHOWN IN RAISED POSITION)
CANOPY JETTISON EXTERNAL D-HANDLE (EACH SIDE)
CANOPY EXTERNAL LEVER (LEFT SIDE ONLY)
RESCUE
DANGER

FIGURE 4-54. F-5E CANOPY AND CONTROLS

automatically adjusted to correspond with seat position. At the start of the rocket phase, the rocket nozzle will move to the automatically adjusted stop position which aligns the rocket thrust vector to the seat-man CG during ejection.

The seat-adjusting unit consists of an electrically-operated twin-screw-drive actuator. The seat is adjusted by depressing the toggle switch located on the right legbrace, forward to lower the seat and aft to raise it. Total seat travel is five inches.

The shoulder harness inertia-reel mechanism consists of an inertia reel, a locking lever located on the left legbrace, and a connecting cable. The locking lever has two positions: a forward or MANUAL position, and an aft or AUTOMATIC position. When the lever is in the forward position, the reel is locked against further reelout of


CANOPY PIERCER
SHOULDER HARNESS
MAN/SEAT SEPARATOR STRAP
ANTI-G SUIT HOSE
ELBOW GUARDS
LAP BELT INITIATOR HOSE
HANDGRIPS (STOWED POSITION)
SURVIVAL KIT
INERTIA REEL LOCK LEVER
LAP BELT INITIATOR GROUND SAFETY PIN
HOSE RETENTION STRAP
OXYGEN AND COMMUNICATION LEADS
SEAT SAFETY PIN AND STREAMER
LEGBRACES
CALFGUARD (EXTENDED DURING EJECTION ONLY)
SEAT ADJUSTMENT SWITCH

F-5E SEAT SHOWN

F-5F SEAT IDENTICAL EXCEPT FOR DETAILS OF CANOPY PIERCER

FIGURE 4-55. F-5E/F EJECTION SEAT

the strap; if any slack occurs in the strap, it will be wound taut and the reel will take another locked position. When the lever is in the aft position, the strap is free to reel in or out; however, any excessive load on the strap will lock the reel and it will remain locked until the locking lever is cycled forward through the MANUAL position and aft to the AUTOMATIC position. The reel is locked automatically during seat ejection when the legbraces are raised, regardless of the locking lever position.

The calfguard is hinge-mounted to the bottom forward end of the seat and is held in the stowed position by a spring-loaded lock assembly. During seat ejection, the calfguard is pulled into position by a cable attached between the calfguard and cockpit floor structure, and is held in the down position by a ratcheting downlock assembly.

The left legbrace contains two initiators, a grip-handle and trigger, and a triggering and locking mechanism. The right legbrace is similar to the left legbrace except for incorporation of one additional initiator. Two initiators, one on each legbrace, are connected by hoses to the canopy thruster. Either initiator will jettison the canopy and can be fired by squeezing its respective legbrace trigger. A second initiator on each legbrace is connected by a hose to the seat-rocket catapult and is fired 0.30 seconds after either legbrace trigger is squeezed. The third initiator on the right legbrace is used to disconnect the lapbelt and operate the seat/man separator system one second after the seat is ejected from the airplane. The legbraces are held in the raised position by arms and spring-loaded uplocks mounted on the right and left sides of the lower seat bucket.

The seat ejection sequence is as follows: the legbraces are raised and locked by pulling either legbrace handgrip individually or both handgrips simultaneously to travel limits. Raising the legbraces locks the inertia reel and positions the handgrip triggers for use. Pulling the right or left handgrip trigger fires the corresponding canopy ejection initiator in that legbrace, which activates the canopy thruster, and the canopy is ejected. When either or both initiators are fired, gas pressure from the canopy-ejection initiator fires the seat-ejection 0.3-second delay initiator in either legbrace, which in turn fires the seat catapult and ejects the seat from the airplane.

Upward movement of the seat in the tracks simultaneously pulls the calfguard to the down position, disconnects the oxygen/electrical personal lead, disconnects the anti-g suit disconnect, pulls the lap-belt lanyard free from the seat belt delay initiator (after actuation), disconnects the canopy jettison system, and disconnects the seat adjusting power cable. One second after the seat is ejected, the seat/man separator system and the automatic-opening lap-belt are activated by a delay initiator. The global survival kit is released at the pilot's discretion by pulling the release handle located at the right front corner of the kit container.

F-5F System. The F-5F escape system is identical to the F-5E system except for details of the seat canopy piercer design. The F-5F seats operate independently and are not sequenced on ejection.

## Oxygen System

Breathing oxygen used in the F-5E/F is supplied from a 5-liter liquid oxygen system. The F-5E system capacity is more than sufficient for 100% oxygen use during the longest mission (ferry mission) where only 47% of its rated capacity is required. The F-5F system capacity is also sufficient for 100% oxygen use during the ferry mission to meet maximum oxygen requirements of two crew members. Under normal oxygen usage conditions for the same F-5F ferry flight, only 32% of the converter capacity is required for two crew members.

Liquid oxygen is stored in the converter unit, which changes the liquid into gaseous oxygen in the buildup section where its temperature is increased. Gaseous oxygen is normally supplied to the cockpit oxygen regulator in the pressure range of 65 to 110 psi. The oxygen regulator controls the flow and pressure of oxygen in proper proportions to meet the pilot's requirements throughout the entire aircraft altitude range. The F-5E oxygen system is serviced with liquid oxygen from a standard TMU-27M or MA-1 liquid oxygen supply cart (or equivalent) through a combination filler-vent valve on the left side of the fuselage. The F-5F oxygen system does not require a LOX supply cart since the converter is fitted with quick disconnects and is readily removable from the aircraft through a quick access door. The converter is then filled away from the aircraft at the liquid oxygen supply source. Once filled, the liquid oxygen will evaporate gradually at the rate of about one liter (liquid) every 24 hours, and vent off into the atmosphere. All the liquid oxygen in either system can be drained through a drain valve in approximately 15 minutes.

The F-5E oxygen system is illustrated in Figure 4-56. It consists of a combination valve with vent and buildup positions, a converter to change liquid oxygen into a gas, and an oxygen regulator and liquid oxygen quantity indicator located in the cockpit. The combination valve is fully automatic in operation, switching to the vent position when the filler hose nozzle is inserted, and back to the buildup position when the nozzle is withdrawn.

The converter consists of an inner and outer stainless steel tank, separated by an area of high vacuum for insulating purposes. The converter also has a buildup coil, pressure-closing valve, relief valve and piping — all arranged to pressurize the liquid oxygen. A heat exchanger coil is installed in the aircraft to convert the liquid oxygen to gas, and deliver the warmed gas to the regulators. Since the process of liquid oxygen evaporation continues as long as liquid remains in the converter, oxygen in the gaseous state will bleed off as pressure builds up in the system due to heat absorption by the converter.

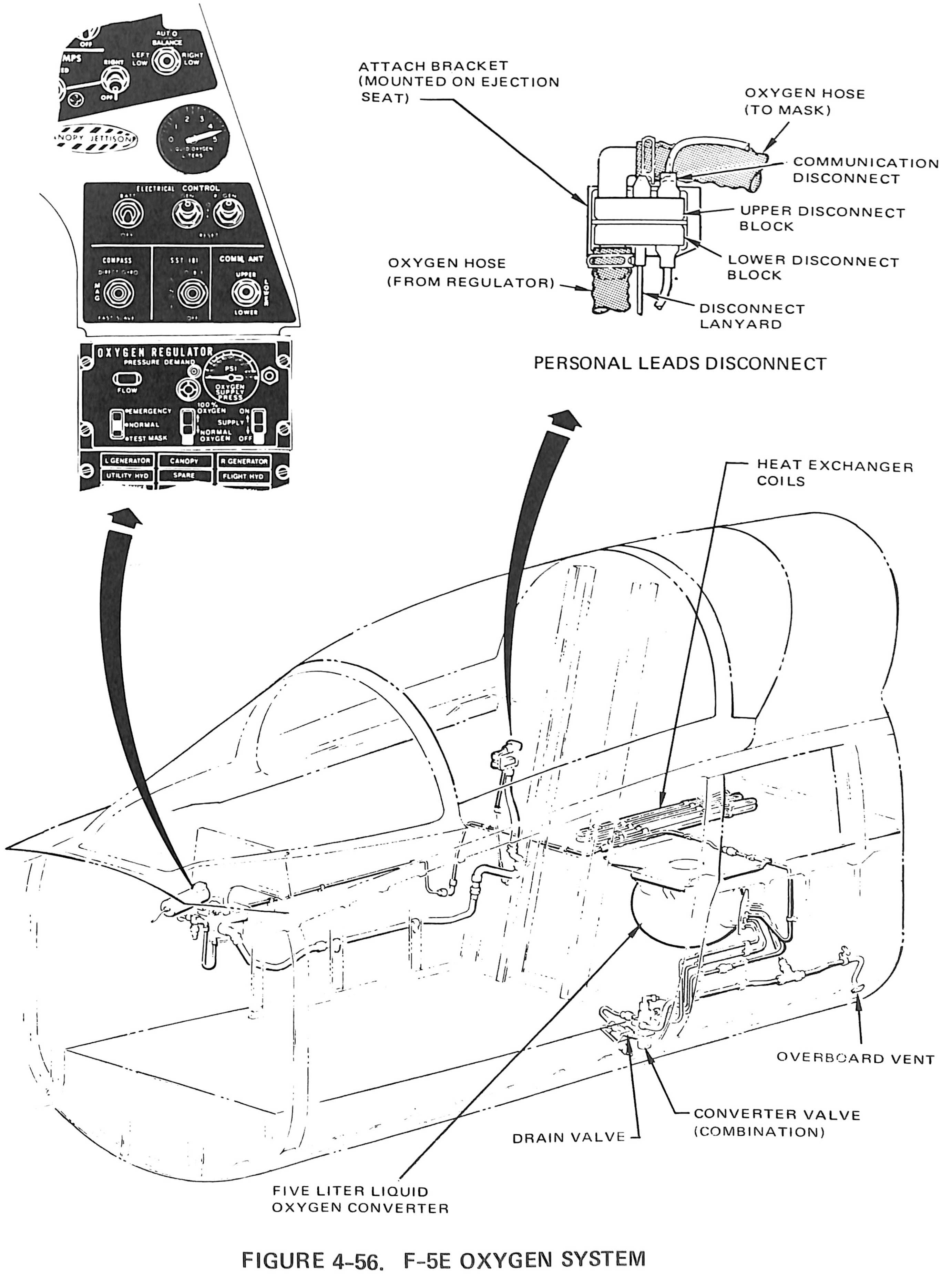

AUTO
BALANCE
LEFT LOW
RIGHT LOW
CANOPY JETTISON
LIQUID OXYGEN LITERS
ELECTRICAL CONTROL
COMPASS
COMM ANT
UPPER
LOWER
OXYGEN REGULATOR
PRESSURE DEMAND
FLOW
PSI
OXYGEN SUPPLY PRESS
EMERGENCY
NORMAL
TEST MASK
100% OXYGEN
NORMAL OXYGEN
SUPPLY
ON
OFF
L GENERATOR
CANOPY
R GENERATOR
UTILITY HYD
SPARE
FLIGHT HYD
ATTACH BRACKET (MOUNTED ON EJECTION SEAT)
OXYGEN HOSE (TO MASK)
COMMUNICATION DISCONNECT
UPPER DISCONNECT BLOCK
LOWER DISCONNECT BLOCK
OXYGEN HOSE (FROM REGULATOR)
DISCONNECT LANYARD
PERSONAL LEADS DISCONNECT
HEAT EXCHANGER COILS
OVERBOARD VENT
CONVERTER VALVE (COMBINATION)
DRAIN VALVE
FIVE LITER LIQUID OXYGEN CONVERTER

FIGURE 4-56. F-5E OXYGEN SYSTEM

A test switch is provided in the cockpit (front cockpit only in the F-5F) to test the quantity indicator and to check oxygen quantity. An oxygen light on the caution light panel (both cockpits in the F-5F) indicates when one-half liter of oxygen remains or when the system pressure to the regulator is reduced to 42 psig.

### Anti-G Suit System

Air pressure from the ninth stage of each engine compressor is used to inflate the anti-g suit to offset the effect of high-g maneuvers. The anti-g suit valve is controlled by weights which are displaced by gravity during the application of normal positive loads which increase the amount of pressure permitted to enter the suit in direct proportion to the severity of the positive normal load factor. A push-to-test button on the top of the suit valve allows manual testing of the system. The valve is connected to the suit through a quick-disconnect block assembly on the upper left side of the ejection seat. This assembly consists of an upper and lower disconnect block, suit fittings, latching mechanism, and a release lanyard. When the seat is jettisoned, the release lanyard attached to the airplane structure actuates the latching mechanism, separating the disconnect blocks. At separation, the upper block remains with the anti-g suit and the lower block with the aircraft. Except for the dual installation, the F-5F system is identical to the F-5E.

### Controls/Displays

The following text describing controls and displays applies to the F-5E and generally to the front cockpit of the F-5F. Figures 4-57, 4-58 and 4-59 show the layout of controls and displays in the F-5E and front and rear cockpits of the F-5F respectively. Table 4-5 is a tabulation of the controls and indicators available in each cockpit of the F-5F. Reference to the figures and table should be made to determine the specific location of each display and control provided in the cockpit(s) of the F-5E or F-5F aircraft.

The lead computing sight and the radar indicator occupy the central area of the instrument panel. The angle-of-attack indexer is located above the panel. Primary flight control displays are located on the left side of the instrument panel. Engine and aircraft system information is displayed on the right side, and the drag chute T-handle and landing gear control are mounted to the left of the panel. The instrument panel is vibration-isolated.

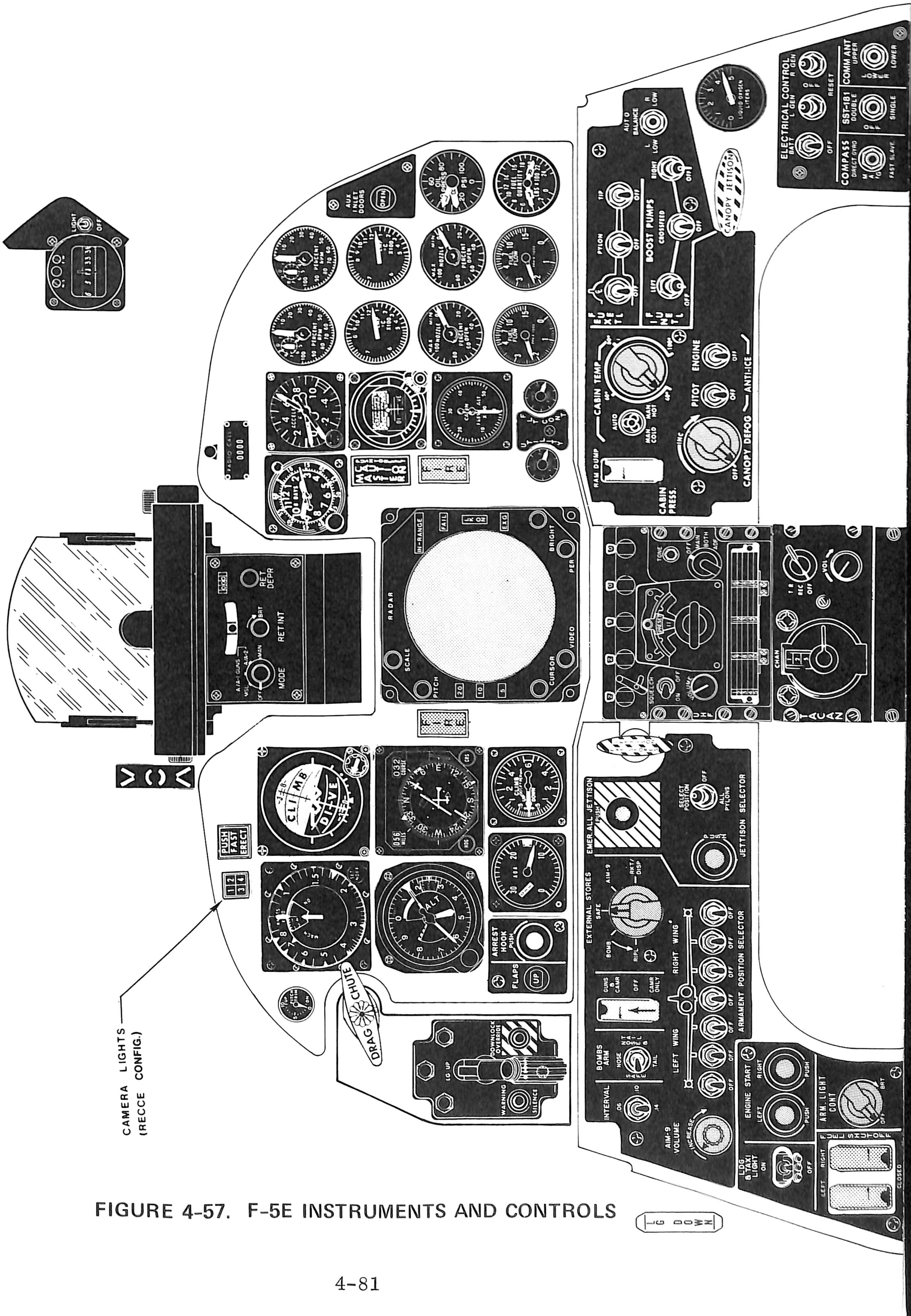

CAMERA LIGHTS
(RECCE CONFIG.)
LIGHT
OFF
AUX INLET DOORS
OPEN
OIL PRESS
PSI
PERCENT RPM
NOZZLE
PERCENT OPEN
FUEL FLOW
FUEL QUANTITY
LIQUID OXYGEN LITERS
ELECTRICAL CONTROL
BAT
L GEN
R GEN
OFF
RESET
COMM ANT
UPPER
LOWER
COMPASS
DIRECT GYRO
FAST SLAVE
SST-181
DOUBLE
SINGLE
AUTO BALANCE
BOOST PUMPS
CROSSFEED
LEFT
RIGHT
OFF
TIP
PYLON
FUEL EXT
FUEL INT
CANOPY JETTISON
CABIN TEMP
AUTO
MAN COLD
MAN HOT
ENGINE
PITOT
ANTI-ICE
CANOPY DEFOG
RAM DUMP
CABIN PRESS.
RADIO CALL
0000
ACCEL
MACH
ALT
RET DEPR
RET INT
BRT
MODE
A/A-1 GUNS
A/A-2
MSL
MAN
OFF
RADAR
IN-RANGE
FAIL
EXG
BRIGHT
PER
SCALE
PITCH
CURSOR
VIDEO
20
10
5
TONE
VOL
CHAN
SQUELCH
UHF
TACAN
PUSH FAST ERECT
CLIMB
DIVE
032
056
MILES
CLIMB
AOA
ALT
ARREST HOOK PUSH
FLAPS
UP
DRAG CHUTE
LG UP
DOWNLOCK OVERRIDE
WARNING
SILENCE
EMER ALL JETTISON
PUSH
SELECT POSITION
ALL PYLONS
OFF
JETTISON SELECTOR
EXTERNAL STORES
SAFE
AIM-9
RKT/DISP
BOMB
RIPL
RIGHT WING
LEFT WING
ARMAMENT POSITION SELECTOR
GUNS & CAMR
CAMR ONLY
BOMBS ARM
NOSE
SAFE
NOSE & TAIL
TAIL
INTERVAL
.06
.10
.14
AIM-9 VOLUME
INCREASE
ENGINE START
LEFT
RIGHT
PUSH
ARM. LIGHT CONT
BRT
OFF
LDG & TAXI LIGHT
ON
OFF
FUEL SHUTOFF
CLOSED
LG DOWN

FIGURE 4-57. F-5E INSTRUMENTS AND CONTROLS

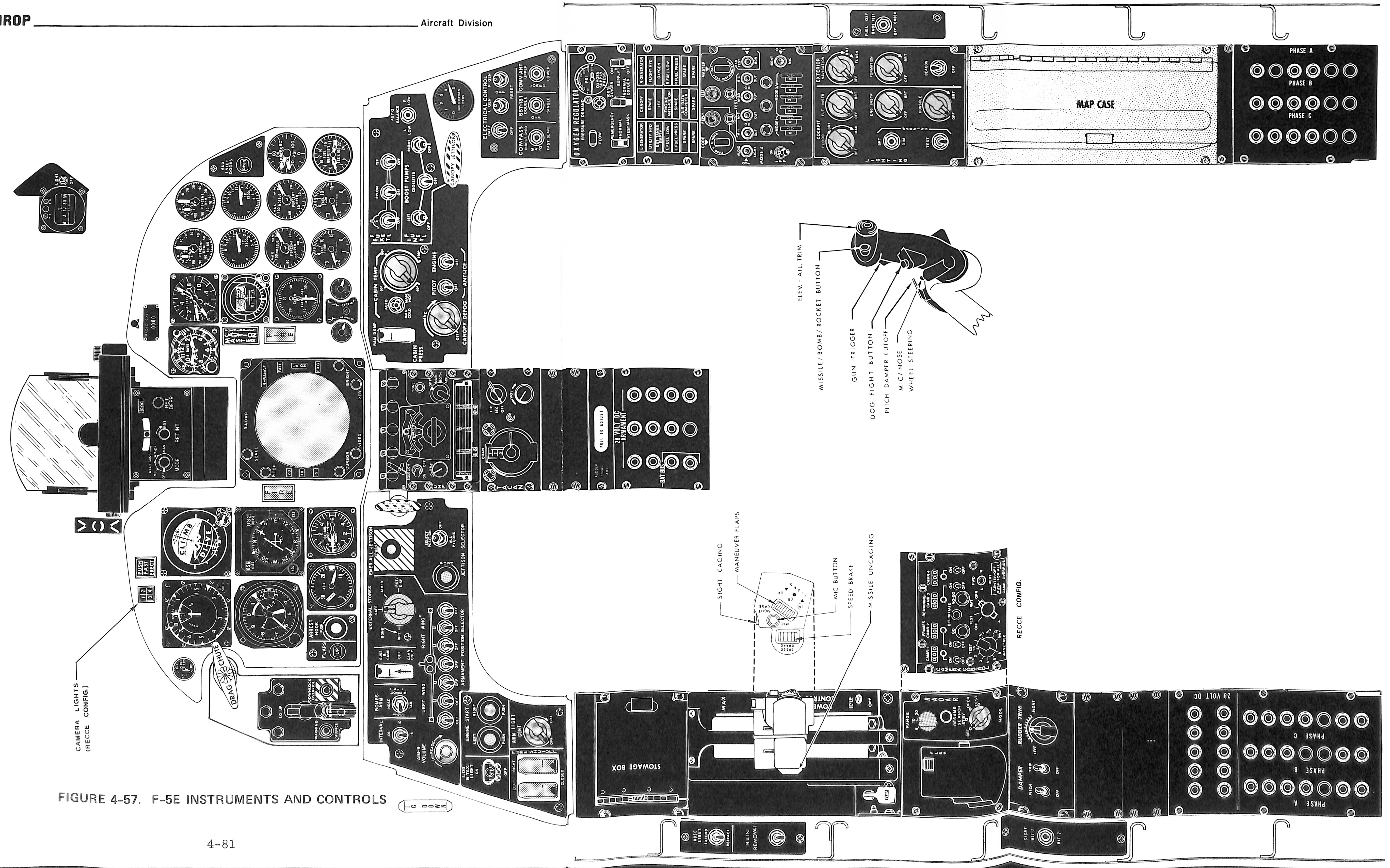

MAP CASE
PHASE A
PHASE B
PHASE C
OXYGEN REGULATOR
ELECTRICAL CONTROL
COMPASS
COMM ANT
SST-181
EXTERIOR
COCKPIT
LIGHTING
FUEL QTY GAGE TEST
BOOST PUMPS
CANOPY JETTISON
CABIN TEMP
CABIN PRESS.
PITOT
ENGINE
ANTI-ICE
CANOPY DEFOG
RAM DUMP
ELEV. - AIL TRIM
MISSILE/BOMB/ROCKET BUTTON
GUN TRIGGER
DOG FIGHT BUTTON
PITCH DAMPER CUTOFF
MIC/NOSE WHEEL STEERING
RADAR
SCALE
PITCH
VIDEO
CURSOR
BRIGHT
PER
RET DEPR
RETINT
MODE
RADIO CALL
28 VOLT DC ARMAMENT
PULL TO ADJUST
BAT BUS
TACAN
CLIMB
DIVE
PUSH FAST ERECT
ARREST HOOK
FLAPS
DRAG CHUTE
EMER ALL JETTISON
JETTISON SELECTOR
EXTERNAL STORES
ARMAMENT POSITION SELECTOR
RIGHT WING
LEFT WING
INTERVAL
BOMBS ARM
AIM-9 VOLUME
ENGINE START
ARM LIGHT CONT
FUEL SHUTOFF
LDG & TAXI LIGHT
LG DOWN
SIGHT CAGING
MANEUVER FLAPS
MIC BUTTON
SPEED BRAKE
MISSILE UNCAGING
CAMERA CONTROL
RECCE CONFIG.
MAX
IDLE
STOWAGE BOX
RADAR
RUDDER TRIM
DAMPER
28 VOLT DC
PHASE C
PHASE B
PHASE A
NOSE STRUT
RAIN REMOVAL
SIGHT BIT 1
BIT 2
CAMERA LIGHTS (RECCE CONFIG.)

FIGURE 4-57. F-5E INSTRUMENTS AND CONTROLS

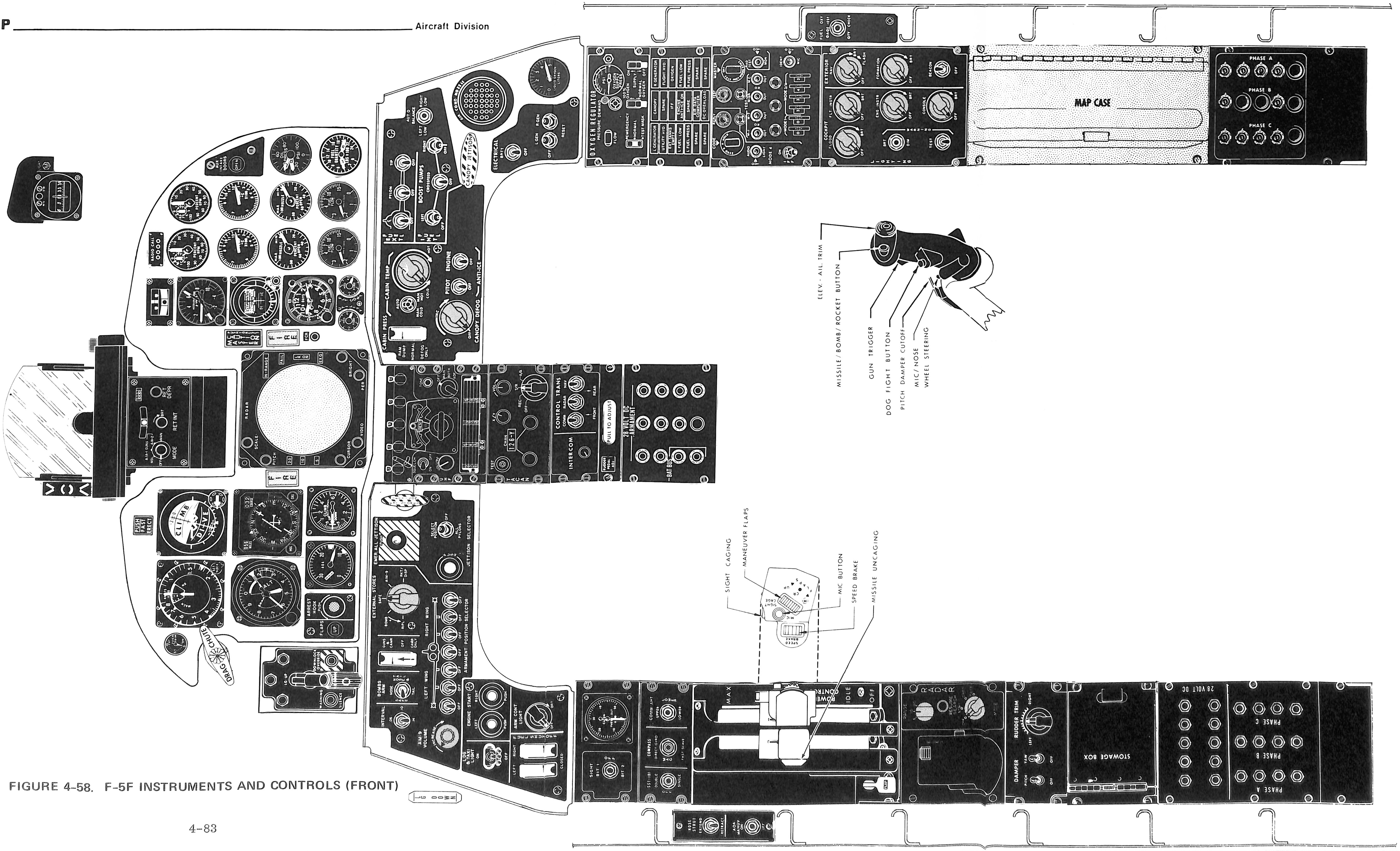

ELEV - AIL TRIM
MISSILE/BOMB/ROCKET BUTTON
GUN TRIGGER
DOG FIGHT BUTTON
PITCH DAMPER CUTOFF
MIC/NOSE WHEEL STEERING
SIGHT CAGING
MANEUVER FLAPS
MIC BUTTON
SPEED BRAKE
MISSILE UNCAGING
MAP CASE
PHASE A
PHASE B
PHASE C
OXYGEN REGULATOR
EXTERIOR
FORMATION
BEACON
COCKPIT
LIGHTING
ELECTRICAL
BOOST PUMPS
CANOPY JETTISON
CABIN TEMP
CABIN PRESS
ENGINE
PITOT
CANOPY DEFOG
ANTI-ICE
RADIO CALL
RADAR
FIRE
RET DEPR
RET INT
MODE
CONTROL TRANS
INTERCOM
TACAN
PULL TO ADJUST
28 VOLT DC ARMAMENT
BAT BUS
PUSH FAST ERECT
CLIMB
DIVE
DRAG CHUTE
ARREST HOOK
FLAPS
EMER ALL JETTISON
JETTISON SELECTOR
EXTERNAL STORES
ARMAMENT POSITION SELECTOR
RIGHT WING
LEFT WING
BOMBS ARM
INTERVAL
AIM-9 VOLUME
ENGINE START
ARM CONT LIGHT
LDG & TAXI LIGHT
LG DOWN
MAX
POWER CONTROL
IDLE
OFF
RADAR
DAMPER
RUDDER TRIM
STOWAGE BOX
28 VOLT DC

FIGURE 4-58. F-5F INSTRUMENTS AND CONTROLS (FRONT)

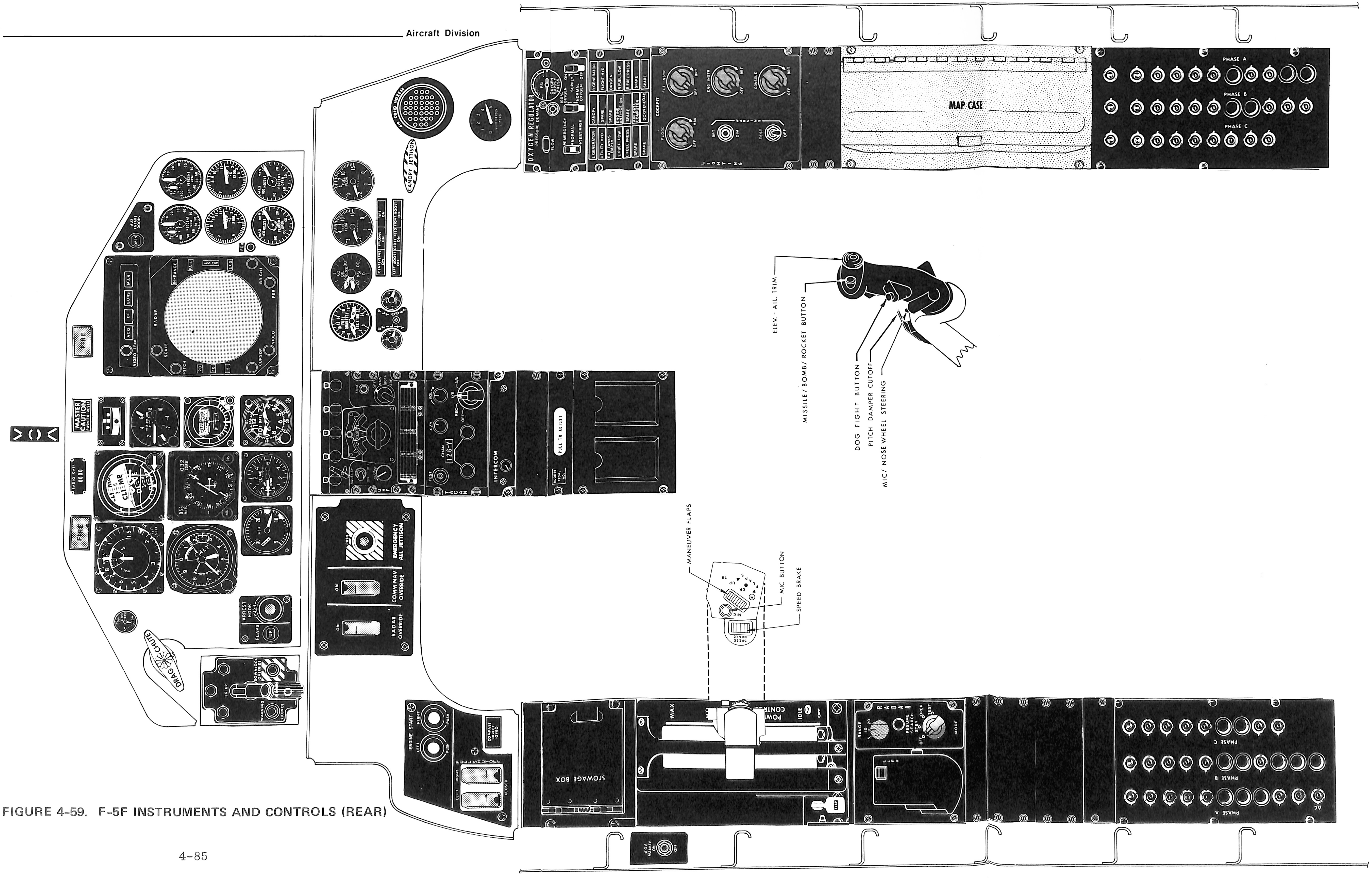

MAP CASE
PHASE A
PHASE B
PHASE C
OXYGEN REGULATOR
CANOPY JETTISON
FIRE
MASTER CAUTION
RADAR
INTERCOM
PULL TO ADJUST
TACAN
EMERGENCY ALL JETTISON
COMM NAV OVERRIDE
RADAR OVERRIDE
ARREST HOOK
FLAPS
DRAG CHUTE
ENGINE START
STOWAGE BOX
POWER CONTROL
MAX
IDLE
ELEV. - AIL. TRIM
MISSILE/BOMB/ROCKET BUTTON
DOG FIGHT BUTTON
PITCH DAMPER CUTOFF
MIC/NOSE WHEEL STEERING
MANEUVER FLAPS
MIC BUTTON
SPEED BRAKE

FIGURE 4-59. F-5F INSTRUMENTS AND CONTROLS (REAR)

## TABLE 4-5. F-5F CONTROL AND INDICATOR FUNCTIONS (SHEET 1 OF 2)

| CONTROL/INDICATOR | FRONT COCKPIT | REAR COCKPIT |
|---|---|---|
| GUNSIGHT WITH BIT | X | — |
| SIGHT CAGING CONTROL | X | — |
| DOGFIGHT BUTTON | X | X |
| RADAR INDICATOR | X | X |
| RADAR TRANSFER CONTROL | X | — |
| RADAR OVERRIDE CONTROL | — | X |
| FIRE CONTROL MODE STATUS LIGHTS | — | X |
| UHF RADIO | X | X |
| UHF ADF | X | X |
| UHF ANTENNA SELECTOR | X | — |
| TACAN | X | X |
| INTERCOM | X | X |
| COMM AND NAV TRANSFER CONTROL | X | — |
| COMM AND NAV OVERRIDE CONTROL | — | X |
| IFF/SIF CONTROL | X | — |
| SKYSPOT CONTROL | X | — |
| ALTIMETER | X | X |
| ATTITUDE INDICATOR | X | X |
| STANDBY ATTITUDE INDICATOR | X | X |
| HORIZONTAL SITUATION INDICATOR | X | X |
| COMPASS CONTROL | X | — |
| COMPASS MODE INDICATOR | — | X |
| GYRO FAST ERECT CONTROL | X | — |
| TACHOMETER (2) | X | X |
| NOZZLE POSITION INDICATOR (2) | X | X |
| OIL PRESSURE INDICATOR | X | X |
| EXHAUST GAS TEMPERATURE INDICATOR (2) | X | X |
| TURN AND SLIP INDICATOR | X | X |
| ANGLE OF ATTACK INDICATOR AND INDEXER | X | X |
| FUEL FLOW RATE INDICATOR (2) | X | X |
| FUEL QUANTITY INDICATOR | X | X |
| HYDRAULIC PRESSURE INDICATOR (2) | X | X |
| VERTICAL SPEED INDICATOR | X | X |
| AIRSPEED MACH NUMBER INDICATOR | X | X |
| ACCELEROMETER | X | X |
| CLOCK | X | X |
| STANDBY COMPASS | X | — |
| CABIN PRESSURE ALTIMETER | X | — |
| ARMAMENT CONTROLS | X | — |
| TRIGGER | X | — |
| EMERGENCY JETTISON BUTTON | X | X |
| MISSILE/BOMB/ROCKET BUTTON | X | X |
| MISSILE UNCAGING SWITCH | X | — |
| TAKEOFF TRIM POSITION INDICATOR | X | X |
| LANDING GEAR CONTROL | X | X |
| ALTERNATE LANDING GEAR RELEASE | X | — |
| CANOPY JETTISON T-HANDLE | X | X |
| FIRE WARNING INDICATORS | X | X |
| AUXILIARY INTAKE DOOR INDICATOR | X | X |
| ARRESTING HOOK CONTROL | X | X |

## TABLE 4-5. F-5F CONTROL AND INDICATOR FUNCTIONS (SHEET 2 OF 2)

| CONTROL/INDICATOR | FRONT COCKPIT | REAR COCKPIT |
|---|---|---|
| DRAG CHUTE CONTROL | X | X |
| NOSE STRUT CONTROL | X | — |
| FLAP CONTROL | X | X |
| FLAP INDICATOR | X | X |
| MANEUVER FLAP CONTROL | X | X |
| MANEUVER FLAP CONTROL TRANSFER/OVERRIDE | — | X |
| SPEED BRAKE CONTROL | X | X |
| STABILITY AUGMENTER/RUDDER TRIM CONTROLS | X | — |
| PITCH DAMPER CUTOFF SWITCH | X | X |
| ELEVATOR-AILERON TRIM CONTROL | X | X |
| FUEL MANAGEMENT CONTROLS | X | — |
| FUEL CONTROL INDICATORS | — | X |
| FUEL/OXYGEN GAGE TEST/QUANTITY CHECK SWITCH | X | — |
| FUEL SHUTOFF CONTROL | X | X |
| THROTTLE | X | X |
| THROTTLE SHUTOFF FINGERLIFTS | X | — |
| ENGINE START CONTROLS | X | X |
| NOSE WHEEL STEERING BUTTON | X | X |
| CABIN CONDITIONING CONTROLS | X | — |
| ANTI-ICE CONTROLS | X | — |
| LOX QUANTITY INDICATOR | X | X |
| OXYGEN REGULATOR CONTROL | X | X |
| EXTERIOR LIGHTS CONTROLS | X | — |
| INTERIOR LIGHTS CONTROLS | X | X |
| ELECTRICAL SYSTEM CONTROL | X | — |
| CAUTION LIGHTS | X | X |

The center pedestal contains controls requiring frequent adjustment or readout in flight. UHF communication controls occupy the prime area (top). Controls for TACAN, rudder pedal adjustment, and a direct-current armament circuit breaker panel are located below the UHF controls.

The left vertical console area contains armament controls, a landing and taxi light switch, engine-start control, and emergency fuel shutoff control.

The right vertical console includes cabin conditioning and related controls, and the internal and external fuel controls, electrical controls, emergency canopy jettison handle, oxygen quantity gage, Sky Spot (radar transponder) control switch, compass mode selector switch, and antenna selector.

The area forward of the power control on the left horizontal console is used for stowage of flight status safety pins and other miscellaneous equipment. Radar controls, rudder trim and stability augmenter switches, provisions for avionic growth, and circuit breaker panels, are aft of the power control. The two-position nose gear switch and rain removal switch are mounted between the frames outboard of the power control. The gunsight BIT (built-in-test) switch is similarly mounted outboard of the radar controls.

The right horizontal console contains the oxygen regulator control, caution light panel, IFF control, lighting control, map case, and circuit breaker panel.

A MASTER CAUTION yellow light, located on the right instrument panel, illuminates when any light on the caution light panel comes on and will go out when the caution light goes out. However, the master caution light may be extinguished by pressing the light assembly. This re-arms the light to provide warning of subsequent malfunctions. The caution light panel contains 21 individual system work capsules. All capsule caution lights are yellow and will remain on as long as a malfunction exists. They will not go out if the master caution light is re-armed. Refer to the description of the various aircraft systems for operation of the applicable caution light.

Two red fire warning lights, one for each engine, are located in the center of the instrument panel, one on each side of the radar indicator. A landing gear red unsafe warning light is located in the landing gear control handle, and the three gear position indicator green lights are located immediately above the landing gear control handle.

The control stick grip contains a trigger, trim button, missile/bomb/rocket button, fire control system dogfight button, microphone/nosewheel-steering button and a pitch damper cutoff switch. The trigger is inoperative in the rear cockpit in the F-5F.

## LIGHTING EQUIPMENT

### Cockpit Lighting

Cockpit lighting systems include the instrument lights, floodlights, console lights, thunderstorm lights, and utility lights. Each system has variable brightness controls. All systems normally operate from primary aircraft AC power. The instrument panel floodlights automatically switch to DC battery power at a fixed intensity in the event of complete AC power failure. Location of lights and controls is shown in Figure 4-60.

The instrument lights are white, 5-volt, integrally lighted and provide primary illumination for the instruments and indicators.

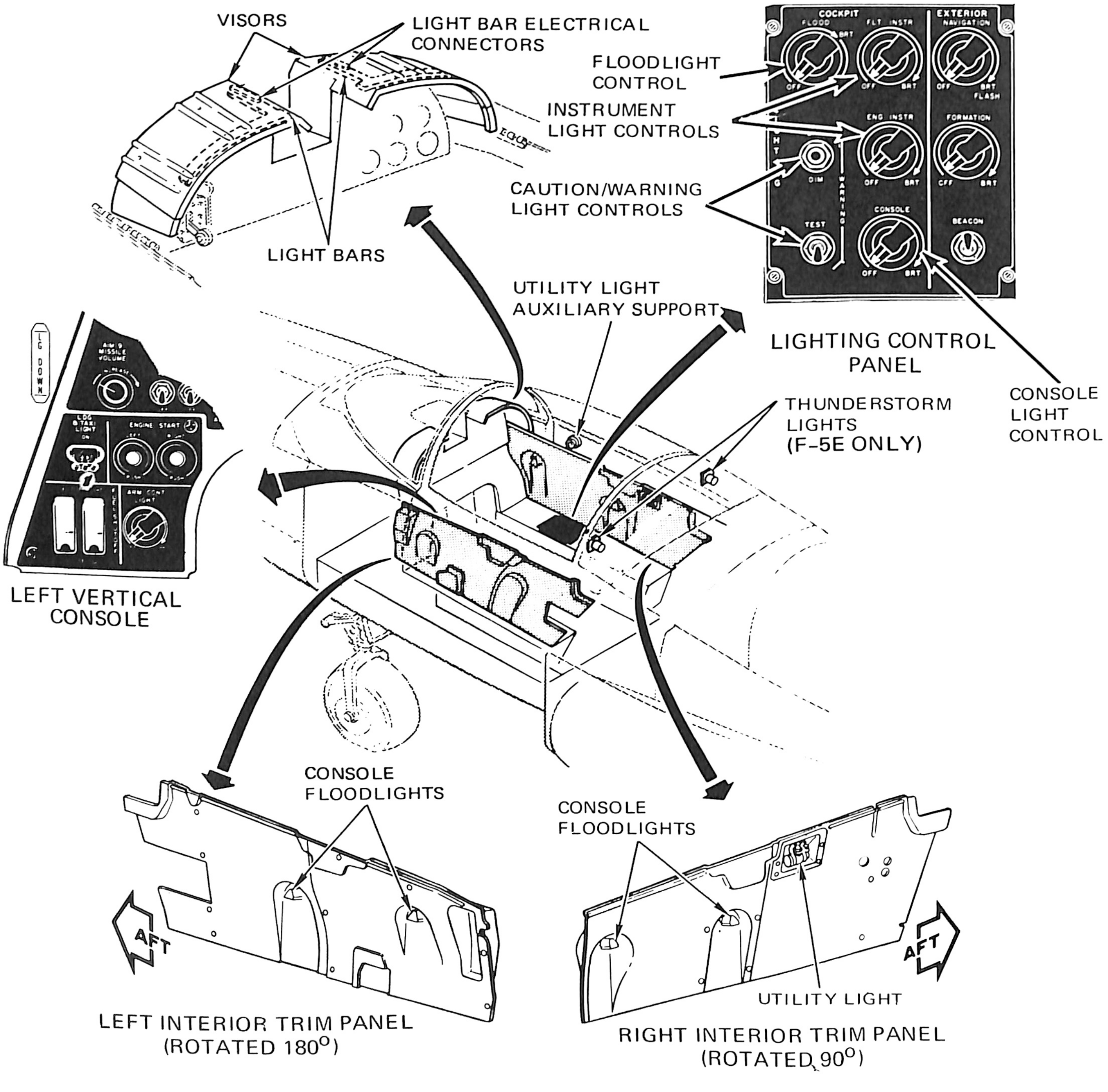

VISORS
LIGHT BAR ELECTRICAL CONNECTORS
FLOODLIGHT CONTROL
INSTRUMENT LIGHT CONTROLS
CAUTION/WARNING LIGHT CONTROLS
LIGHT BARS
UTILITY LIGHT AUXILIARY SUPPORT
LIGHTING CONTROL PANEL
CONSOLE LIGHT CONTROL
THUNDERSTORM LIGHTS (F-5E ONLY)
LEFT VERTICAL CONSOLE
CONSOLE FLOODLIGHTS
CONSOLE FLOODLIGHTS
AFT
AFT
UTILITY LIGHT
LEFT INTERIOR TRIM PANEL (ROTATED 180°)
RIGHT INTERIOR TRIM PANEL (ROTATED 90°)

FIGURE 4-60. F-5E AND F-5F FRONT COCKPIT LIGHTING

The floodlights consist of two light bar assemblies installed on the underside of the instrument panel visors and four console floodlights, two recessed into the interior trim panels on each side of the cockpit. The instrument panel floodlights are white and each is equipped with five lamps rated for 0.70 cp at 28 volts. Instrument panel floodlights provide secondary illumination for the instrument panel and vertical control panels. The console floodlights are white lamps rated for 6 cp at 28 volts, which provide secondary illumination for panels mounted in the left and right horizontal consoles.

Primary console lighting is provided by plastic edge-lighted plates which illuminate the nomenclature and instructions on control assemblies. These plates are designed for white illumination, equipped with lamps rated at 5 volts.

High intensity thunderstorm lights installed in the F-5E canopy structure aft of the pilot's head, are directed toward the primary instrument panel area and are controlled by the floodlight control. Advancing the floodlight control beyond maximum flood intensity, energizes the thunderstorm lights. The F-5F does not have thunderstorm lights.

The utility light is a portable assembly equipped with a lamp rated for 3.3 cp at 28 volts. The primary stowage position for this light is in a cavity recessed in the right interior trim panel of the F-5E and the front cockpit in the F-5F. It is stowed on the canopy in the rear cockpit of the F-5F. The assembly is equipped with a coil-cord extension, and it can be removed from its mounting base to hand-hold or attach to an auxiliary support provided in the cockpit. The assembly is approximately 3.63 inches long, with a diameter of 1.75 inches, excluding support. The utility light is controlled by an OFF/DIM rheostat/switch which is an integral part of the assembly. Controls on the assembly also permit selection of floodlighting, spotlighting, or pushbutton signaling with either red or white light.

With the exception of the utility and armament control lights, the variable brightness controls for interior lighting systems are located on the lighting control panel in the right console of the F-5E and front cockpit of the F-5F (Figure 4-60). The F-5F rear cockpit lighting controls are shown in Figure 4-61. The armament lighting control is located in the left vertical panel below the armament controls (F-5F front cockpit only). The instrument and console lights are controlled by variable voltage output autotransformer devices. The floodlights are controlled by a solid-state variable dimming device. Also located on the lighting control panel are the BRT/DIM and the lamp TEST switches. The BRT/DIM switch provides two-level intensity control for

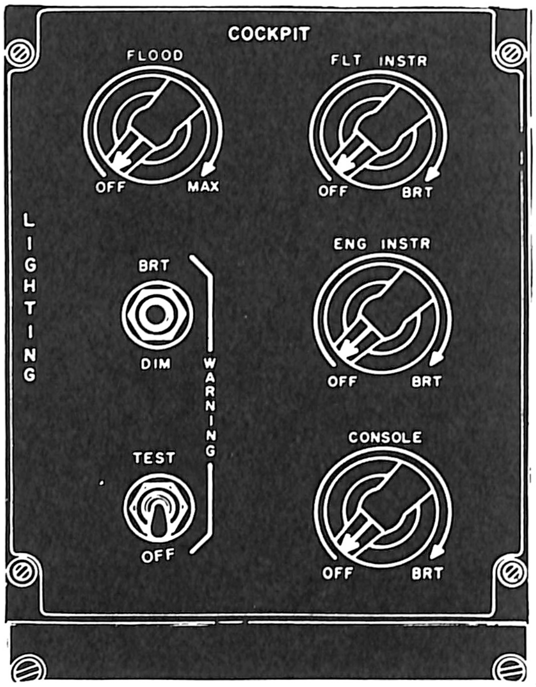


FIGURE 4-61. F-5F REAR COCKPIT LIGHTING CONTROLS

the caution, warning and indicator lights. The TEST switch permits test activation of all caution, warning and indicator lights as well as the landing gear audible warning signal.

### Landing/Taxi Lights

Two combination landing/taxi lights are provided, one in the lower surface of each engine inlet duct as shown in Figure 4-62. These lights are electrically controlled to extend and retract automatically as a function of landing gear position, weight of the aircraft on/off the main gear, and exterior navigation light operation. Illumination of the lamps is controlled by a pilot-operated ON-OFF toggle switch in the cockpit (front cockpit only in the F-5F).

When the aircraft is on the ground, switching the navigation lights to ON (front cockpit only in F-5F) extends the lights to the taxi position. In this taxi position, the light beams are directed 0.5 degree down from the aircraft HRL at an intensity of 37,500 cp each. After takeoff, these lights retract flush when the landing gear is retracted or when the navigation lights are turned OFF. In the landing position, the beams are automatically aimed approximately 11.5 degrees down from the aircraft HRL at an intensity of 250,000 cp. Upon touchdown, when the weight of the aircraft is on the main gear, the light assemblies automatically retract to the taxi position and the lights reduce to low-intensity.

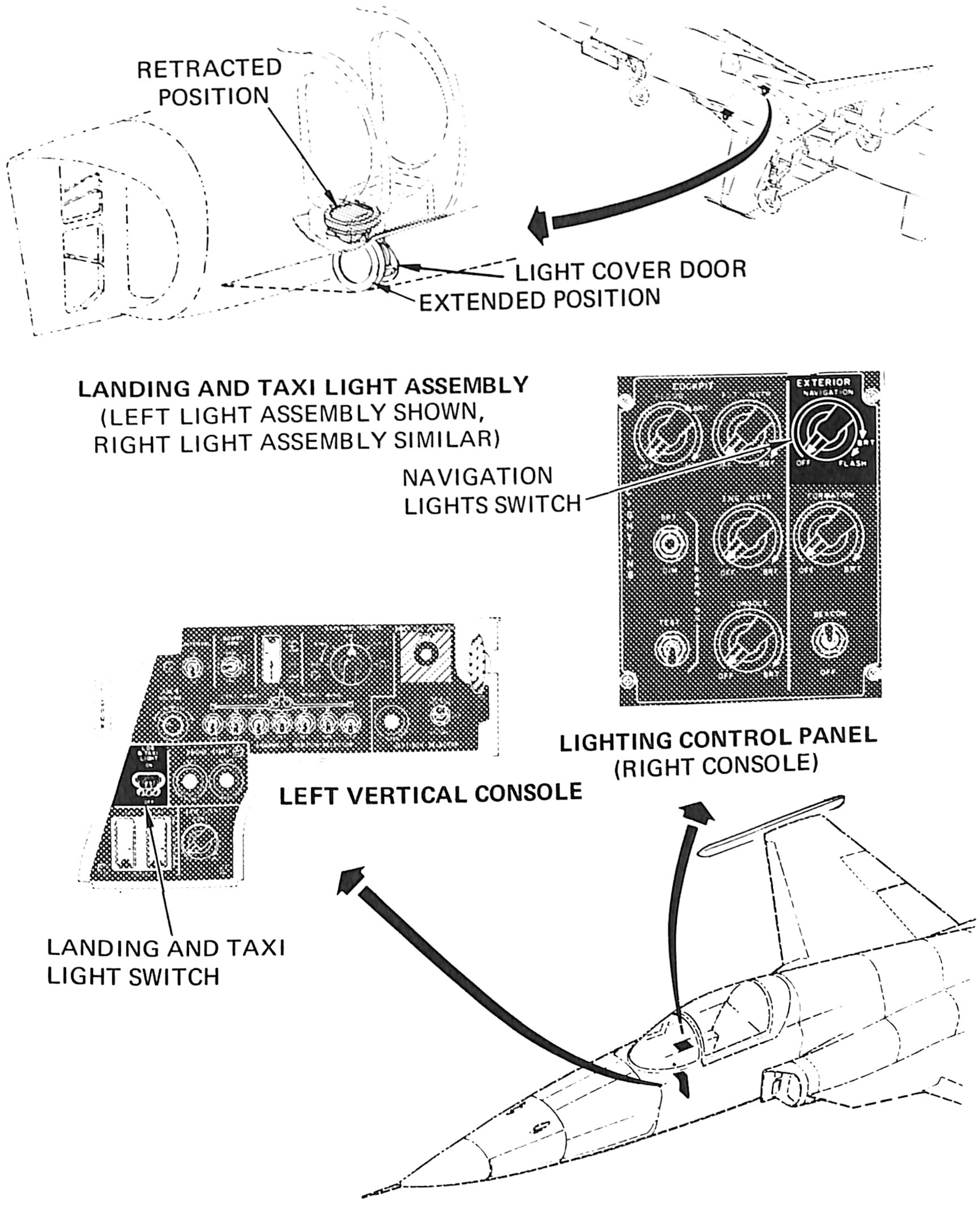

RETRACTED POSITION
LIGHT COVER DOOR
EXTENDED POSITION
LANDING AND TAXI LIGHT ASSEMBLY
(LEFT LIGHT ASSEMBLY SHOWN,
RIGHT LIGHT ASSEMBLY SIMILAR)
NAVIGATION LIGHTS SWITCH
EXTERIOR
NAVIGATION
OFF
FLASH
LIGHTING CONTROL PANEL
(RIGHT CONSOLE)
LEFT VERTICAL CONSOLE
LANDING AND TAXI LIGHT SWITCH

FIGURE 4-62. LANDING AND TAXI LIGHTS

### Rotary Beacon (Anticollision Light)

The red rotary beacon light is installed near the top of the vertical stabilizer as shown in Figure 4-63. The mounting flanges are essentially flush with the contours of the vertical stabilizer, and the lenses protrude approximately 3/8-inch outside the moldlines to permit viewing the light from behind the aircraft. The light is controlled by a simple ON/OFF switch located in the pilot's lighting control panel on the right horizontal console (front cockpit only in F-5F), and is not dimmable or interlocked with any other aircraft system.

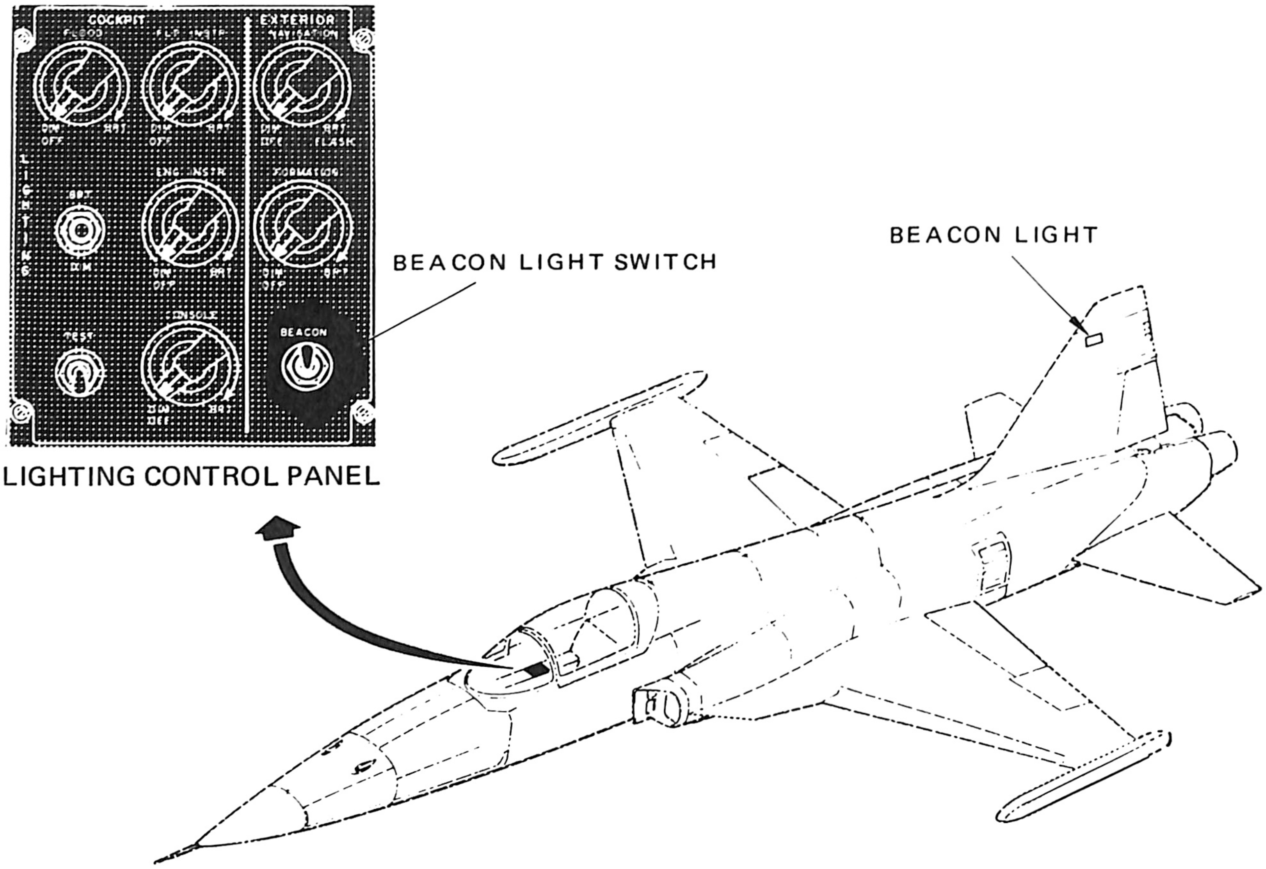

COCKPIT
FLOOD
FLT INSTR
EXTERIOR
NAVIGATION
DIM
OFF
BRT
FLASH
LIGHTING
ENG INSTR
FORMATION
CONSOLE
TEST
BEACON
BEACON LIGHT SWITCH
BEACON LIGHT
LIGHTING CONTROL PANEL

FIGURE 4-63. ROTARY BEACON (ANTICOLLISION LIGHT)

The light consists of a housing, two red lenses, two 24-volt, 40-watt (4000 candle power) lamps with sockets, one 115-volt to 24-volt step-down lamp transformer, one 115-volt ac 320-480 Hz motor, one base and reflector assembly mounted to a mechanism assembly driven by a motor, and a disconnect terminal panel. Light from the bulbs is reflected by the rotating reflector into the horizontal plane to provide a flashing effect. Flash rate varies between 49 and 83 flashes per minute, depending on operating voltage and frequency. Light coverage in the horizontal plane is blanked approximately 1 degree on either side of centerline in the aft direction, and 20 degrees either side of centerline in the forward direction. The light assembly is designed for a minimum of 1000 hours of service.

### Navigation and Formation Lights

The navigation lights consist of two white lower fuselage lights, one red (left) and one green (right) primary position light, two white vertical stabilizer lights, one red (left) wingtip and one green (right) wingtip auxiliary position light, as shown in Figure 4-64. The two lower fuselage lights have white-diffused lenses and are located below the cockpit, one on each side of the aircraft centerline. The vertical stabilizer lights are located near the upper tip and have a white diffused lens on each side.

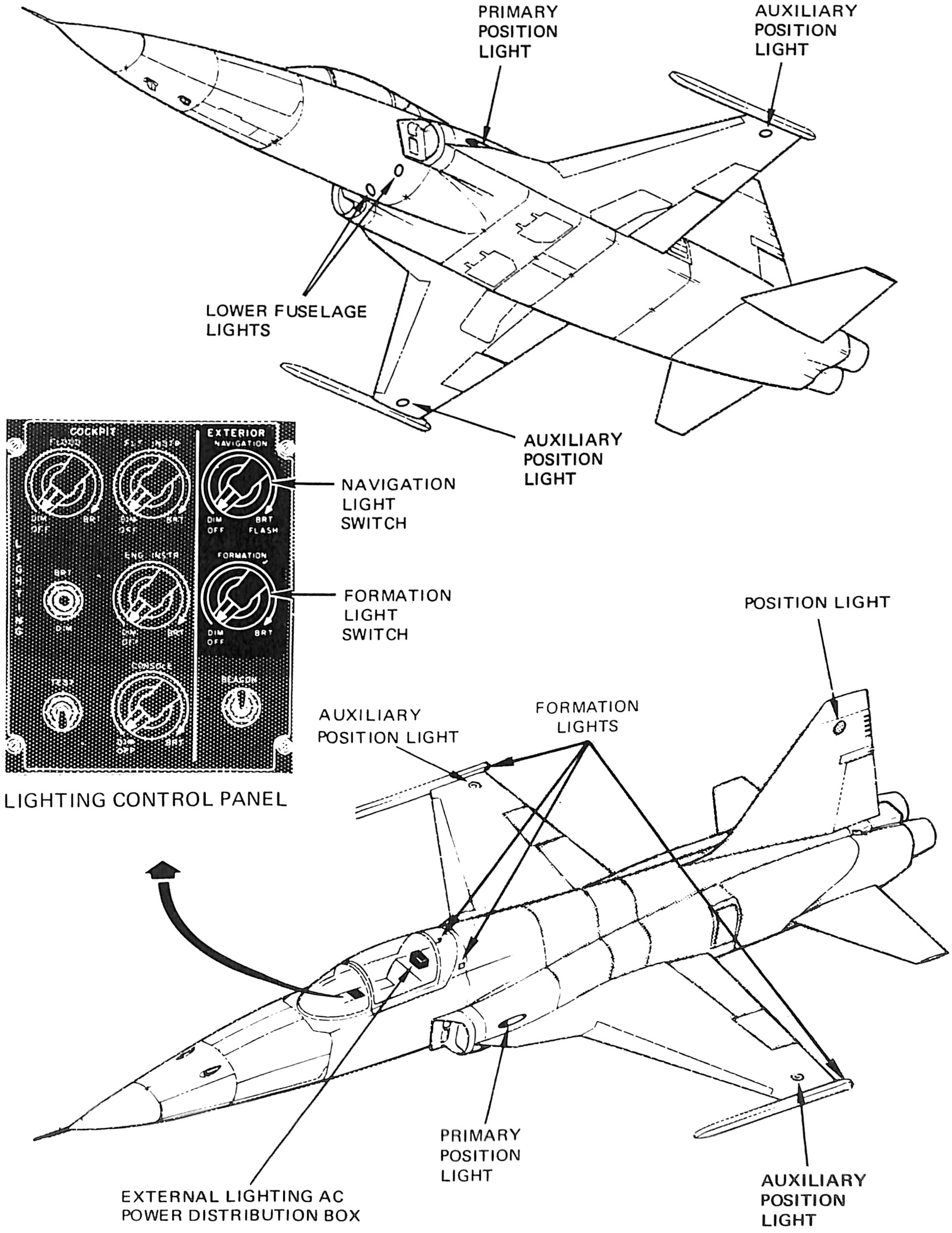

PRIMARY POSITION LIGHT
AUXILIARY POSITION LIGHT
LOWER FUSELAGE LIGHTS
AUXILIARY POSITION LIGHT
COCKPIT
FLOOD
FLT INSTR
EXTERIOR
NAVIGATION
DIM
BRT
OFF
FLASH
FORMATION
ENG INSTR
LIGHTING
TEST
CONSOLE
BEACON
NAVIGATION LIGHT SWITCH
FORMATION LIGHT SWITCH
LIGHTING CONTROL PANEL
POSITION LIGHT
AUXILIARY POSITION LIGHT
FORMATION LIGHTS
PRIMARY POSITION LIGHT
EXTERNAL LIGHTING AC POWER DISTRIBUTION BOX
AUXILIARY POSITION LIGHT

FIGURE 4-64. NAVIGATION AND FORMATION LIGHTS

The wingtip lights, red (left) and green (right), are also recessed into the honeycomb structure, and are located near the wingtips with lenses above and below the wings. The outboard and aft sectors of the lower lenses are diffused to prevent bright filament annoyance to formation wing pilots. The upper lenses are similar to the lower, except they are opaqued in the direction of the pilot to prevent reflection in the canopy, and have a clear diffused segment inboard which illuminates the aft fuselage and vertical stabilizer. These lights use 6-volt, single-filament lamps.

The formation lights consist of two incandescent light fixtures, one flush-mounted on each side of the canopy fairing just aft of the cockpit and two incandescent light fixtures; one mounted in each launcher rail, red (left) and green (right). These lights are 6-volt, single-filament lamps.

The navigation and formation lights are controlled by individual controls located on the light control panel in the right console as shown for the F-5E in Figure 4-64. Controls are located in the front cockpit only for the F-5F. The navigation light control can be used to energize the lights in any of the three following modes: (1) variable intensity wing auxiliary position lights with tail lights of a fixed dim intensity, (2) wing auxiliary position, primary position, and tail lights steady-bright and (3) primary position and tail lights bright/flash and auxiliary position and lower fuselage lights steady/bright. The formation light control provides continuously variable control from off to bright.

## AVIONICS AND INSTRUMENTS

This section describes the F-5E/F UHF command radio, UHF/ADF, intercommunication system, IFF/SIF system, TACAN system, X-band radar transponder, attitude and heading reference system (AHRS), central air data computer (CADC), pitot static system and angle of attack system. Discussion of the standby compass and standby attitude reference is included with the AHRS. The flight instruments are discussed in the pitot static system description. The UHF radio, intercom, and IFF/SIF systems operate on DC power and can be operated even with double generator failure.

### UHF Command Radio System

The AN/ARC-150(V)9 UHF command radio set* provides two-way voice or tone communications at line-of-sight ranges. The set operates in the ultrahigh frequency range between 225 MHz and 399.975 MHz, with 10 watts rated minimum RF power output during transmissions. Channel centers are separated by 25 KHz, providing a total of 7000 channels, of which any 20 may be preset in any order on the control panel. A separate guard channel is provided in addition to the 20 preset channels. The command radio operational parameters are summarized in Table 4-6.

---

* The VHF command radio and alternate ARC-164 UHF command radio set options are described in Appendix A.

TABLE 4-6. AN/ARC-150 UHF COMMAND RADIO PARAMETERS

| PARAMETER | FEATURE/RANGE |
|---|---|
| OPERATING ENVIRONMENT | 0 TO 50,000 FEET IN A TEMPERATURE ENVIRONMENT UP TO PLUS 71°C (+158° F). |
| STORAGE ENVIRONMENT | MINUS 62°C TO PLUS 85°C (-79°F TO +185°F). |
| POWER | 27.5 VOLTS DC, 30 WATTS – RECEIVE, 90 WATTS – TRANSMIT. |
| WARMUP TIME | 30 SECONDS MAXIMUM. |
| DUTY CYCLE | 1 MINUTE TRANSMIT, 5 MINUTES RECEIVE. |
| FREQUENCY RANGE | 225.00 MHz TO 399.975 MHz SPACED AT 25 KHz INTERVALS. |
| FREQUENCY CHANNELS | 7,000. |
| FREQUENCY ACCURACY | PLUS OR MINUS 2,000 Hz. |
| PRESET CHANNELS | 20 (PLUS GUARD CHANNEL). |
| GUARD FREQUENCY RANGE | 238.00 TO 248.00 MHz (CRYSTAL INSERTION). |
| CHANNEL CHANGING TIME | 1 SECOND, MAXIMUM. |

The F-5E system consists of the AN/ARC-150(V)9 Radio Set, with the receiver/transmitter and control panel all integrated in one unit, and the antenna system. The AN/ARC-150 Radio Set is mounted in the pilot's center pedestal. It is all solid state and features electronic tuning.

The F-5F system consists of the AN/ARC-150(V)9 Radio Set, with the receiver/transmitter and control panel all integrated into one unit in the front cockpit, a C8938/ARC-150(V) remote control panel in the rear cockpit, and the antenna system. The

AN/ARC-150 equipment is mounted in the center pedestal in each cockpit. Either front or rear cockpit may control the ARC-150 equipment depending upon the position of the COMM transfer switch on the center pedestal in the front cockpit. The rear cockpit may assume control at any time using the COMM NAV override switch.

Two receivers are incorporated in the radio set: one used for normal communications, and the other for monitoring emergency calls on the guard channel, normally 243 MHz. The guard channel can be monitored simultaneously with the channel selected on the main receiver.

The set controls are shown in Figure 4-65. A function selector switch is provided with four positions designated: OFF, MAIN, BOTH and ADF. The MAIN position permits receiving or transmitting on the selected channel. In the BOTH position, the guard channel is monitored by a separate guard receiver simultaneously with the selected channel. In the ADF position, the selected receiver channel is switched to the ADF antenna; and the guard receiver is turned off. If the transmitter is keyed in this mode the ADF antenna is automatically disconnected and the transmitter output is switched to the forward UHF communications antenna.

The frequency selector mode control provides the following types of frequency selection: MANUAL, PRESET and GUARD. In the MANUAL mode, the frequency for receiving and transmitting is selected by means of five controls located along the upper portion of the panel. The frequency selected is displayed in windows above the control.

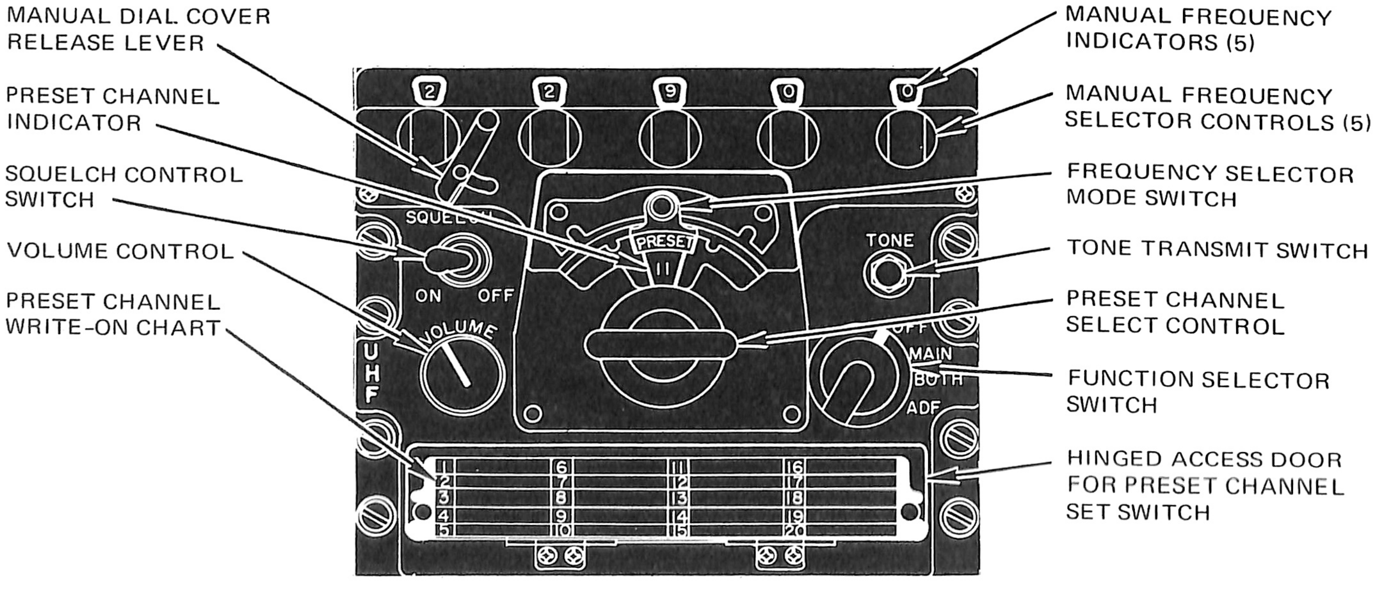

MANUAL DIAL COVER RELEASE LEVER
PRESET CHANNEL INDICATOR
SQUELCH CONTROL SWITCH
VOLUME CONTROL
PRESET CHANNEL WRITE-ON CHART
MANUAL FREQUENCY INDICATORS (5)
MANUAL FREQUENCY SELECTOR CONTROLS (5)
FREQUENCY SELECTOR MODE SWITCH
TONE TRANSMIT SWITCH
PRESET CHANNEL SELECT CONTROL
FUNCTION SELECTOR SWITCH
HINGED ACCESS DOOR FOR PRESET CHANNEL SET SWITCH
2
2
9
0
0
SQUELCH
ON
OFF
VOLUME
UHF
PRESET
11
TONE
OFF
MAIN
BOTH
ADF
1 2 3 4 5
6 7 8 9 10
11 12 13 14 15
16 17 18 19 20

FIGURE 4-65. RADIO SET CONTROLS

In the PRESET position, any one of 20 preset operating channels may be selected by a single control located in the center of the panel. The set has a spring-return push-button located behind the access panel on which the channel chart is mounted. Depressing the switch transfers the frequency displayed on the frequency indicator dials to an electronic memory for the channel indicated on the preset channel selector. Once set up, the frequency will continue to be selected by that channel number until changed by dialing a new frequency and depressing the button. Each channel is set up by the same procedure.

In the GUARD position, the main receiver and transmitter are tuned to the guard channel. The guard receiver and the guard preset frequency controls are electrically disabled in this mode.

A spring-return push-button marked TONE on the right hand side allows the pilot to transmit tone modulated signal.

A volume control is located on the left-hand side of the panel and controls the audio output level of the receiver. A switch above the volume control marked SQUELCH allows the squelch of the main receiver output to be turned on or off.

The UHF antenna system consists of two omnidirectional antennas; one is a combination UHF/IFF blade mounted on the lower forward fuselage, and the other is located within the removable vertical stabilizer tip assembly. A Type SA-521 radio frequency transmission line switch connects the transmitter/receiver to the antenna system. A three-position switch located in the cockpit on the right hand vertical console of the F-5E provides for manual positioning of the SA-521 switch between the upper and lower antennas. This switch is located in the left hand vertical console in the F-5F front cockpit only.

### UHF Automatic Direction Finder (ADF)

The AN/ARA-50 UHF ADF system operates in conjunction with the UHF command radio to provide bearing indication to any ground or airborne UHF station to which the radio is tuned. The relative bearing information is displayed on the Horizontal Situation Indicator (HSI) (both cockpits in the F-5F) when ADF is selected on the AN/ARC-150 control. The AN/ARA-50 operates in the 225 to 400 MHz UHF frequency range. A UHF station is acquired by proper channel (frequency) selection on the UHF command radio which receives the incoming UHF station modulated signal (tone or voice) through the ADF antenna. The UHF station signal from the antenna is fed through the

UHF command radio to an amplifier relay assembly where the angle between the direction to the UHF station and the direction the ADF antenna is pointing establishes an error signal. The error signal from the amplifier relay assembly is fed back to the ADF antenna and the ADF antenna is caused to rotate within its housing until it is pointing at the incoming signal from the UHF station. The direction that the ADF antenna is pointing is displayed on the HSI as the relative bearing to the selected UHF station.

Bearing slewing speed averages 60 degrees per second from any starting point which is 50 degrees to 179 degrees from the signal, and at least 12 degrees per second from any starting point less than 50 degrees and more than 10 degrees from the signal, including the time required for the pointer to reach normal action when on bearing. Under service conditions, inherent bearing error is less than ± 5 degrees. The indicated bearing does not lag the on-course bearing by more than 5 degrees at an aircraft turning rate of 3 degrees per second.

The AN/ARA-50 direction finder group consists of the AS-2755/ARA antenna and the AM-3624/ARA-50 amplifier relay assembly. The AS-2755/ARA antenna is solidly mounted on the lower surface of the fuselage immediately aft of FS 194 in the F-5E and just forward of FS 87.5 in the F-5F. The antenna assembly contains the receiving elements, antenna lobing switch and servomechanism for rotating the antenna.

The AM-3624/ARA-50 Amplifier Relay Assembly is mounted in the aft equipment bay in the F-5E and the forward equipment bay of the F-5F. It is vibration-isolated by an MT-1955/ARA-50 mount. The amplifier relay assembly amplifies and filters the square wave signal from the antenna lobing switch and develops the output to drive the antenna drive motor. It also contains circuitry to switch the AN/ARC-150 Radio Set from the UHF communications antenna system to the ADF antenna when ADF is selected on the AN/ARC-150 control. Keying of the transmitter by the pilot at any time will cause the transmitter output to be switched back to the forward UHF communications antenna.

The AN/ARA-50 will operate at optimum performance for 200 hours or more without adjustment of controls which are inaccessible during flight. The equipment has an MTBF of 1000 hours and a total operating life greater than 2000 hours.

### Intercommunication System

The F-5E intercom system provides headset amplification for the UHF radio, the radio-navigation systems, maneuvering flaps and landing gear audio warning signals, the AIM-9 missile tones, as well as microphone preamplification control of the UHF radio transmission and cockpit-to-ground crew voice communications. Components of the system include a microphone amplifier interconnecting junction box, headset amplifier interconnecting junction box, headset amplifier (AN/AIC-18 or -25), microphone amplifier (AN/AIC-18 or -25), two microphone switches, personal leads disconnect, power filter, and a ground maintenance intercom receptacle.

The ground receptacle, located behind an access door on the right wing fillet area (FS 291), provides communication between the cockpit and maintenance personnel when an AN/AIC-17 ground maintenance intercom system is connected. The maintenance intercom can be used either as a single ground station (power supplied by the aircraft) or as a multiple-place ground station when an AN/AIC-17 power supply is used.

The throttle-quadrant microphone switch keys the UHF command radio transmission and identification-of-position transmission when this mode is selected at the IFF Control Panel. The nosewheel steering button is an alternate microphone switch when the aircraft is airborne. A personal lead disconnect fitting enables quick disconnect of the microphone and headset leads from the aircraft when the seat is ejected.

In the F-5F, the intercom system provides all of the audio functions described above and in addition, provides communication between the front and rear cockpits. An intercom control panel in each cockpit is equipped with a single combination push-pull switch/volume control to provide each pilot an individual control of audio of the intercom system. Communication between the aircrew is available when this switch is in the ON position in either or both cockpits. The headset and microphone amplifiers in the F-5F are AN/AIC-25.

### IFF/SIF System

The AN/APX-72 IFF/SIF* (identification friend or foe/selective identification feature) system shown in Figure 4-66, provides positive identification of an aircraft, whenever challenged by a ground, shipboard, or airborne IFF recognition installation (RI); and provides automatic altitude reporting in 100-foot increment data obtained from the central air data computer. Upon receipt of an RI challenge, the system decodes the interrogating signal, encodes a reply, and automatically transmits the coded reply back to the RI where it is visually displayed on an indicating device such as a search-radar plan position indicator. The system receives and transmits Mark X-IFF signals supplemented by the selective identification feature. Four operating modes are available: M-1 provides 32 pilot selectable military codes, M-2 provides 4096 military codes (any one preset prior to flight), M-3/A provides 4096 pilot selectable civil/military codes, and Mode C provides automatic altitude reporting of corrected pressure altitude computed by the CADC. Complete provisions for a KIT-1A/TSEC

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* An alternate AN/APX-101 IFF/SIF system is described in Appendix A.

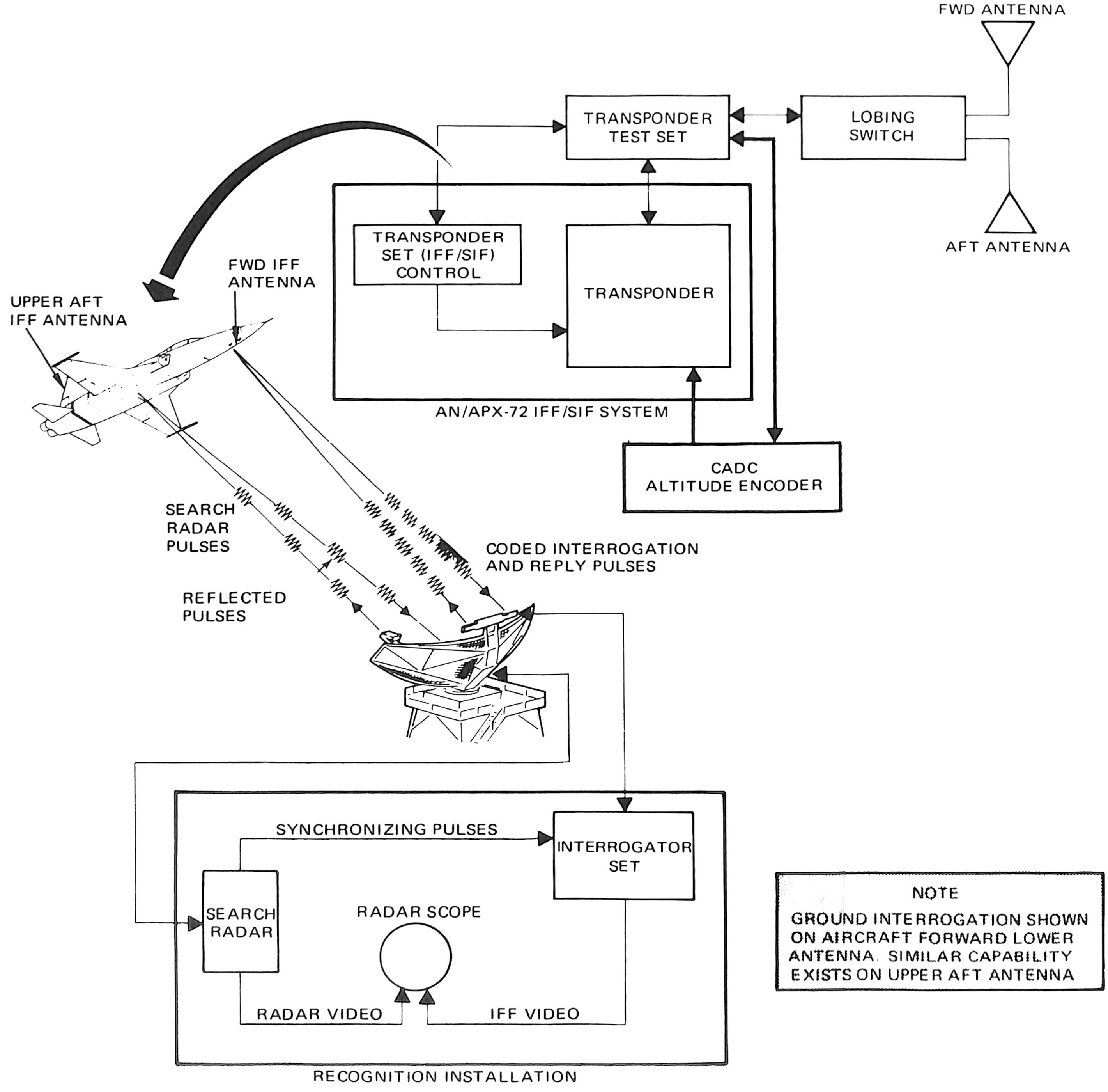

FWD ANTENNA
TRANSPONDER TEST SET
LOBING SWITCH
AFT ANTENNA
TRANSPONDER SET (IFF/SIF) CONTROL
TRANSPONDER
AN/APX-72 IFF/SIF SYSTEM
CADC ALTITUDE ENCODER
UPPER AFT IFF ANTENNA
FWD IFF ANTENNA
SEARCH RADAR PULSES
REFLECTED PULSES
CODED INTERROGATION AND REPLY PULSES
SYNCHRONIZING PULSES
INTERROGATOR SET
SEARCH RADAR
RADAR SCOPE
RADAR VIDEO
IFF VIDEO
RECOGNITION INSTALLATION
NOTE
GROUND INTERROGATION SHOWN ON AIRCRAFT FORWARD LOWER ANTENNA. SIMILAR CAPABILITY EXISTS ON UPPER AFT ANTENNA

FIGURE 4-66. IFF/SIF BLOCK DIAGRAM

computer are incorporated in the aircraft for Mode 4 (classified) security identity. Receiver and transmitter operation occurs in the ultrahigh-frequency bands, limiting usable range to line of sight between the airplane and the RI. Components comprising the system include an AN/APX-72 transponder, C-6280(P)/APX transponder set control, TS-1843 A or B test set, SA-1474/A lobing switch, two L-band antennas, and two antenna test receptacles. The system is operated from the aircraft DC power system except for the SA-1474/A switch which is AC powered.

The transponder is hermetically sealed and requires no cooling air while operating over the temperature range of -54°C to +71°C. Maintenance procedures are simplified in that the transponder contains throwaway RF components instead of tubes, and thus the need for realignment is minimized. The unit is estimated to have an MTBF of 500 hours.

The transponder set control shown as Figure 4-67 is mounted in the cockpit (installed in and controlled from the front cockpit only in the F-5F) and provides remote control of the system. Located on the front panel of this unit are two knob-actuated rotary switches, eight toggle switches and six thumbwheel-actuated rotary switches. The thumbwheel switches are used to select reply code numbers to interrogation modes 1 and 3 for the transponder. Each mode-enabling toggle switch has a momentary TEST position which permits a comparison of simulated interrogation signals with the resulting replies. Favorable comparisons are indicated by illumination of the TEST light. The MASTER rotary switch turns the transponder on or off, controls transponder receiver sensitivity, and provides for manual selection of the emergency code transmission.

Aircraft equipped with a KIT-1A/TSEC computer are capable of being preset with a Mode 4 classified discrete frequency. The IFF caution light on the caution light panel comes on when Mode 4 interrogations are not properly processed and replied to or when Mode 4 is zeroed.

The TS-1843 A or B test set monitors performance of the transponder and (in conjunction with the C-6280(P)/APX Control) permits in-flight operation checks. Upon command, the test set will interrogate the transponder and indicate satisfactory transponder performance on a go/no-go basis; or the test set can monitor the response to an externally generated interrogation and indicate satisfactory performance on a go/no-go basis.

The IFF antenna system consists of two directional antennas; one is a horizontal slot in the vertical stabilizer for aft hemispheric coverage and the other is the L-band portion of the combination UHF/IFF blade mounted on the lower forward fuselage for

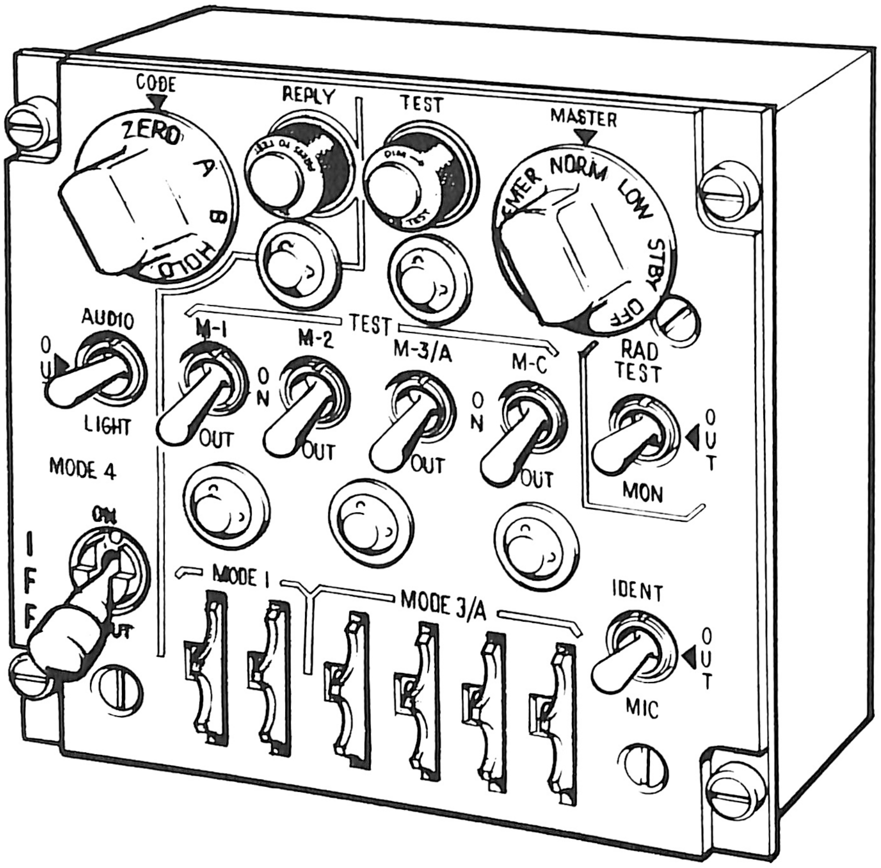

CODE
ZERO
A
B
HOLD
REPLY
TEST
MASTER
EMER
NORM
LOW
STBY
OFF
AUDIO
OUT
LIGHT
TEST
M-1
M-2
M-3/A
M-C
ON
OUT
OUT
ON
OUT
OUT
RAD TEST
OUT
MON
MODE 4
ON
IFF
OUT
MODE 1
MODE 3/A
IDENT
OUT
MIC

FIGURE 4-67. IFF/SIF TRANSPONDER SET CONTROL

forward hemispheric coverage. A type SA-1474/A lobing switch continuously cycles the transponder set to each antenna alternately. Each antenna has a ground test receptacle, and a three-position IFF test switch selects either FORWARD ANTENNA, AFT ANTENNA, or BOTH for ground test of the IFF System. This switch is located on the seat rail structure behind the pilot's head in the F-5E and in the same relative location behind the rear cockpit seat in the F-5F.

## TACAN SYSTEM

The AN/ARN-65* TACAN is installed in the F-5E. The AN/ARN-84 TACAN is standard equipment in the F-5F airplane. The AN/ARN-65 TACAN provides distance, bearing, and course information for aircraft navigation. It operates in the L-band frequency range with 126 channels available from 962 MHz to 1213 MHz. Nominal usable range of the system is approximately 195 nautical miles at an aircraft altitude of 40,000 feet, or a proportionately lower range with decreased altitude. The equipment performs the following functions:

---

*Features of the AN/ARN-84 TACAN system which is optional equipment for the F-5E are discussed in Appendix A.

- Displays relative bearing to the ground beacon continuously in the receive and transmit-receive modes.
- Indicates aircraft deviation from the selected course or ground beacon radial in the receive and transmit-receive modes.
- Indicates the distance (slant-range) of the aircraft to the ground beacon in the transmit-receive modes.
- Provides a signal to indicate whether the selected course takes the aircraft toward or away from the beacon in the receive and transmit-receive modes.
- Identifies the ground beacon station being received by aural indication.

Systems components consist of a receiver/transmitter, TACAN set control, TACAN tone filter, and the antenna system.

The TACAN radio set control shown in Figure 4-68 is located on the center pedestal and provides remote control of the system. It consists of a channel selector, a function selector switch, and a volume control. The function selector switch is a three-position rotary switch marked OFF, REC, and T/R. In the REC position the receiving circuits in the receiver/transmitter are energized to provide bearing information and ground beacon identity only; the T/R position energizes both receiving and transmitting circuits in the receiver/transmitter to provide bearing, beacon identity, and distance information. The aural identification signal is fed directly from the receiver to the intercom system. When either the TACAN or IFF/SIF system is transmitting, the transmitting system generates blanking pulses to disable the receiver of the other system. This prevents spurious operation of the other system.

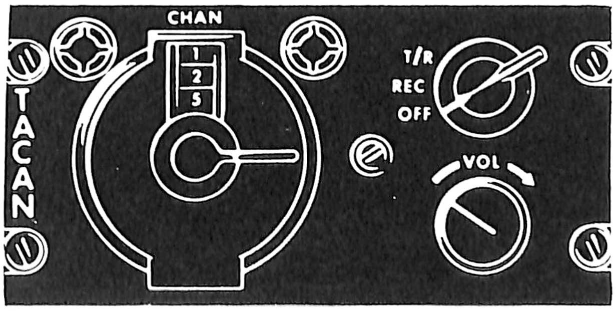


FIGURE 4-68. TACAN SET CONTROL

TACAN information is displayed on the horizontal situation indicator (HSI) as shown in Figure 4-69. This information includes aircraft heading, to/from station indication, TACAN bearing and range, preset course, and course deviation information. Displayed range information is accurate to 0.25 nautical mile, and the displayed magnetic bearing information is accurate within one degree.

The TACAN antenna system consists of two directional L-band antennas; one is a horizontal slot in the vertical stabilizer for aft coverage and the other is a blade antenna mounted on the lower forward fuselage for forward hemispheric coverage. A radio frequency transmission switch connects the receiver/transmitter to the antenna system. The receiver/transmitter controls the switch which automatically selects either the TACAN forward or aft antenna. Each antenna has a ground test receptacle.

### X-Band Radar Transponder

The SST-181 Radar Transponder is a miniaturized encoder-transponder that enhances the tracking capabilities of X-band ground-based SKYSPOT radars, by receiving pulsed interrogations and transmitting high level pulsed replies in the same frequency band.

The radar transponder system consists of an AS-2038/UPN omnidirectional slot array antenna mounted on the upper fuselage surface at Fuselage Station 285; an RT-855/UPN-25 radio receiver-transmitter located at Fuselage Station 280; and a switch on the right vertical control panel in the F-5E for pilot selection of single or double-pulsed reply modes. The F-5F operating controls are on the left horizontal console in the front cockpit only.

The system may be operated in either single pulse or any of nine preselected double pulse codes in response to a single pulse interrogation. Selection of double pulse code spacing is accomplished on the ground prior to flight by switching to one of the nine double pulse codes on the encoder-transponder unit. Double pulse response provides for discrete identification as well as position of a given aircraft or group of aircraft.

The receiver-transmitter is a compact solid-state unit except for the magnetron. It employs a high-performance superheterodyne circuit with a solid triggering sensitivity of at least -65 dbm; typical peak power output is 350 watts.

The RT-855/UPN-25 has a minimum service life of 10,000 hours. Operational stability is 150 hours minimum without readjustment; it operates 250 hours without maintenance and has an MTBF of 1000 hours.

## Attitude and Heading Reference System

The attitude and heading reference system (AHRS) provides heading information to the TACAN system and displays heading information on the horizontal situation indicator. Pitch and roll information is displayed on the attitude indicator and supplied to the fire control radar; roll information is provided to the lead computing sight, as shown in the block diagram portion of Figure 4-69. The AHRS provides an attitude reference with full freedom in three axes (all attitude capability) compatible with air-to-air combat maneuvering requirements.

The AHRS consists of a horizontal situation indicator (HSI), an attitude indicator, a magnetic azimuth detector and compensator, a two-gyro platform, an electronic control amplifier, a rate switching gyro, a compass mode switch, fast erect switch, control unit, power adapter and relay panel, and a power cutoff switch.

The HSI (AQU-13/A) contains a servoed heading card, servoed bearing pointer, manual or servoed course marker, course deviation bar, DEV/DF flag, TO/FROM flag, 3-digit synchro-driven range/distance counter, and range/distance warning flag. The HSI is a 3-inch hermetically sealed unit mounted in the instrument panel (both cockpits in the F-5F), which contains servos and solid-state servo amplifiers, and has an MTBF of 1000 hours.

A TACAN/DF selector relay operated by the UHF radio function selector switch selects either TACAN or DF data for display on the HSI. When the function selector switch is in the DF position, the HSI displays relative bearing to the UHF station being monitored plus aircraft magnetic heading. Any other position of the function selector switch operates the relay to allow TACAN bearing and range, course (TACAN radial), deviation from the desired course and TO/FROM information with respect to the TACAN station to be displayed along with aircraft magnetic heading.

The attitude indicator is a type ARU-20/A 3-inch, 2-axis, hermetically sealed unit mounted on the instrument panel (both cockpits in the F-5F). A two-color sphere indicates the aircraft attitude through 360° in roll and 180° in pitch. A pitch trim knob allows adjustment of the sphere horizon line relative to a miniature airplane. An attitude warning flag (OFF) appears when the AHRS is not operating or during fast erection. The MTBF of the ARU-20/A is 1500 hours.

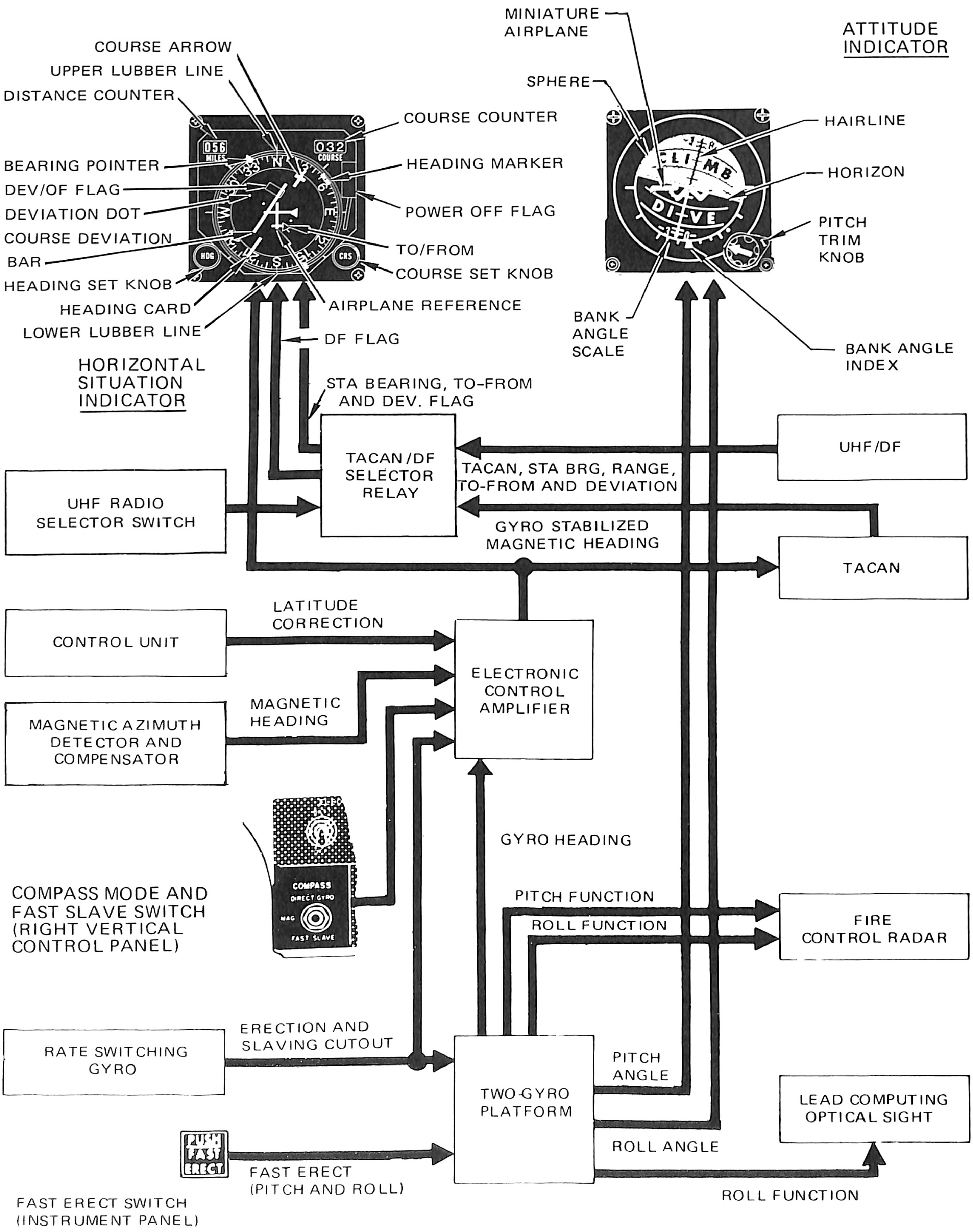

MINIATURE AIRPLANE
ATTITUDE INDICATOR
COURSE ARROW
UPPER LUBBER LINE
DISTANCE COUNTER
SPHERE
COURSE COUNTER
HAIRLINE
BEARING POINTER
HEADING MARKER
HORIZON
DEV/OF FLAG
DEVIATION DOT
POWER OFF FLAG
PITCH TRIM KNOB
COURSE DEVIATION BAR
TO/FROM
HEADING SET KNOB
COURSE SET KNOB
HEADING CARD
AIRPLANE REFERENCE
BANK ANGLE SCALE
LOWER LUBBER LINE
DF FLAG
BANK ANGLE INDEX
HORIZONTAL SITUATION INDICATOR
056 MILES
032 COURSE
N
HDG
CRS
CLIMB
DIVE
STA BEARING, TO-FROM AND DEV. FLAG
TACAN/DF SELECTOR RELAY
UHF/DF
TACAN, STA BRG, RANGE, TO-FROM AND DEVIATION
UHF RADIO SELECTOR SWITCH
GYRO STABILIZED MAGNETIC HEADING
TACAN
LATITUDE CORRECTION
CONTROL UNIT
ELECTRONIC CONTROL AMPLIFIER
MAGNETIC HEADING
MAGNETIC AZIMUTH DETECTOR AND COMPENSATOR
GYRO HEADING
COMPASS
DIRECT GYRO
MAG
FAST SLAVE
COMPASS MODE AND FAST SLAVE SWITCH (RIGHT VERTICAL CONTROL PANEL)
PITCH FUNCTION
ROLL FUNCTION
FIRE CONTROL RADAR
ERECTION AND SLAVING CUTOUT
RATE SWITCHING GYRO
PITCH ANGLE
TWO-GYRO PLATFORM
LEAD COMPUTING OPTICAL SIGHT
PUSH FAST ERECT
ROLL ANGLE
FAST ERECT (PITCH AND ROLL)
ROLL FUNCTION
FAST ERECT SWITCH (INSTRUMENT PANEL)

FIGURE 4-69. ATTITUDE AND HEADING REFERENCE SYSTEM (AHRS)

The magnetic azimuth detector (DT-309/AJN), located in the dorsal at Fuselage Station 385.0, contains a pendulous element which senses the local direction of the horizontal component of the earth's magnetic field and provides the magnetic heading reference. A compensator (CN-1072/AJN) is attached to the magnetic azimuth detector to minimize deviation caused by residual magnetic fields in the aircraft. The detector has an MTBF of 5000 hours.

The two-gyro platform (SBK16/A24G-42) contains a pendulous liquid level gyro erection system which senses the local direction of the earth's gravity field during unaccelerated level flight and provides the aircraft pitch and roll (vertical gyro) data and the gyroscopic heading (directional gyro) reference. This unit is located on the canopy shelf and has an MTBF of 500 hours.

The electronic control amplifier (ECA) (ASK-8A/A 24G-5) contains servo amplifiers, power supply inverter and a servo repeater slaved to the directional gyro heading. Alignment of the directional gyro with the magnetic azimuth detector is accomplished by torquing the gyro until the repeater and the azimuth detector are synchronized. With the compass switch in MAG position, this synchronization is accomplished automatically when power is applied to the ECA, or when the compass switch is moved from DIRECT GYRO to MAG or FAST SLAVE positions. The ECA assembly is located on the canopy shelf and has an MTBF of 1000 hours.

The rate switching gyro disconnects magnetic slaving of the directional gyro and erection of the vertical gyro in roll during aircraft turn rates of 15 degrees per minute or more, to minimize the errors induced in the pendulous magnetic azimuth detector and liquid sensors by turn accelerations. This unit is located in the aft equipment bay and has an MTBF of 1250 hours.

The mode switch, located in the right vertical control panel in the F-5E and the left horizontal console in the F-5F front cockpit only, has three positions: DIRECT GYRO, MAG, and FAST SLAVE. MAG (slaved magnetic) is the normal mode of operation and provides gyro stabilized magnetic heading. In DIRECT GYRO (free directional gyro mode), slaving of the directional gyro to the magnetic azimuth detector is cut off and the gyro stabilized heading output is based on the last magnetic azimuth information before cutoff. The FAST SLAVE mode permits rapid slaving of the directional gyro to the magnetic azimuth detector. The PUSH FAST ERECT switch, located in the upper left-hand instrument panel adjacent to the indicator, (front cockpit only in the F-5F) permits rapid erection of the vertical gyro to the local vertical.

The control unit, located in the aft equipment bay, provides a latitude correction factor which is inserted manually to reduce the apparent gyro drift due to the earth's rotation. A switch is used to select the proper polarity of the correction for northern or southern hemisphere. These are both ground service adjustments.

Standby Compass. Standby heading reference is provided by an AQU-3/A magnetic, fluid dampened, integrally white-lighted compass with an on-off switch to control the illumination. The standby compass is mounted to the windshield bow on the right-hand side above the instrument panel (front cockpit only in the F-5F) (Figure 4-51).

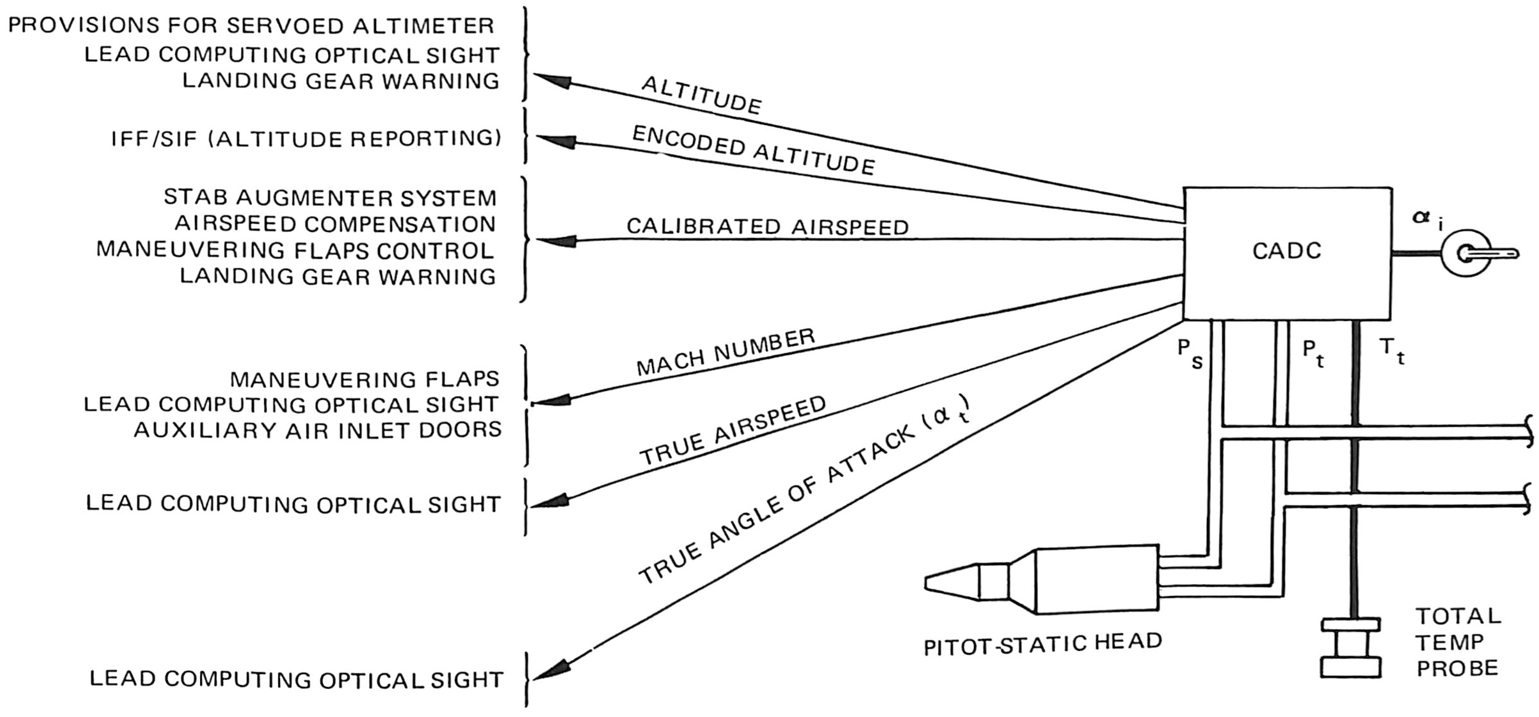
Standby Attitude Reference System. The standby attitude reference system consists of an ARU-32/A self-contained gyro/indicator powered from the aircraft AC electrical system. The indicator is a drum type which displays 360° of roll and +92° to -78° of pitch. The pitch indications are expanded at approximately a 2:1 ratio. A knob on the lower right hand corner is used to trim the indicator ±5° in pitch. Roll angle markings are located on the lower half of the indicator similar to the primary attitude reference indicator. The instrument is located in the right instrument panel in the F-5E and front cockpit of the F-5F (Figures 4-57 and 4-58). The instrument is located in the center of the instrument panel in the F-5F rear cockpit (Figure 4-59).

The gyro/indicator is caged and aligned by pulling the knob and is locked in the caged position by rotating the knob clockwise. A flag is displayed when the system is caged or if there is a loss of power. Nine minutes of useful attitude reference information is provided after complete loss of electrical power.

### Central Air Data Computer (CADC)

The CADC (CPU-118/A) is a compact electromechanical, solid-state computer, which receives total pressure ($P_t$) and static pressure ($P_s$) inputs from the pitot-static head; total temperature ($T_t$) inputs from the total temperature probe, and local angle of attack ($\alpha_i$) from the angle-of-attack transmitter. Using these inputs, the CADC computes the data outputs for various systems as diagrammed in Figure 4-70. CADC computation ranges and accuracies are listed below the diagram in the figure.

The CADC consists of a computer unit and mounting rack located in the avionics compartment in the nose. The front panel contains pitot and static pressure connections, electrical connectors, a self-test switch, go/no-go indication lights, and an elapsed time indicator. The F-5F CADC differs from the F-5E only in that a modification of the angle-of-attack circuit is necessary to accommodate different calibrations and duplicate instrumentation in the rear cockpit.


PROVISIONS FOR SERVOED ALTIMETER
LEAD COMPUTING OPTICAL SIGHT
LANDING GEAR WARNING
IFF/SIF (ALTITUDE REPORTING)
STAB AUGMENTER SYSTEM
AIRSPEED COMPENSATION
MANEUVERING FLAPS CONTROL
LANDING GEAR WARNING
MANEUVERING FLAPS
LEAD COMPUTING OPTICAL SIGHT
AUXILIARY AIR INLET DOORS
LEAD COMPUTING OPTICAL SIGHT
LEAD COMPUTING OPTICAL SIGHT
ALTITUDE
ENCODED ALTITUDE
CALIBRATED AIRSPEED
MACH NUMBER
TRUE AIRSPEED
TRUE ANGLE OF ATTACK ($\alpha_t$)
CADC
$\alpha_i$
$P_s$
$P_t$
$T_t$
PITOT-STATIC HEAD
TOTAL TEMP PROBE

| COMPUTATION | | RANGE/ACCURACY |
|---|---|---|
| ALTITUDE | RANGE: | -1,000 TO 60,000 FEET |
| | ACCURACY: | ±50 FEET OR 5.0% OF INDICATED ALTITUDE (WHICHEVER IS LARGER) |
| ALTITUDE REPORTING | ACCURACY: | ± 25 FEET OR 0.2% OF INDICATED ALTITUDE (WHICHEVER IS LARGER) |
| CALIBRATED AIRSPEED | RANGE: | 0 TO 800 KNOTS |
| | ACCURACY: | TAILORED TO EACH FUNCTION, GENERALLY BETTER THAN ± 3% OF VALUE. |
| MACH NUMBER | RANGE: | 0.5 TO 2.2M |
| | ACCURACY: | ±0.010M |
| TRUE AIRSPEED | RANGE: | 0 TO 1300 KNOTS |
| | ACCURACY: | ±5 KNOTS FROM 120-300<br>±4 KNOTS FROM 300-600<br>±1% OF TAS FROM 600-1300 |
| TRUE ANGLE OF ATTACK | RANGE: | -4° TO 29° |
| | ACCURACY: | ±1° OVER RANGE OF -2° TO +24° |

FIGURE 4-70. CENTRAL AIR DATA COMPUTER INPUTS AND OUTPUTS

The CADC contains self-test and failure monitoring circuits. It can be self-tested by depressing a switch on the front panel of the computer while command values are substituted for basic sensor outputs to test each functional channel. The failure monitor circuit is also tested. The failure monitoring circuitry detects loss of input power and static pressure servo error between 5 and 15 percent of indicated Mach number. Failure warning is indicated on the caution light panel. The F-5E CADC has complete provisions to drive a servoed altimeter and the F-5F CADC can drive two servoed altimeters.

The CADC has a specified MTBF of 1500 hours and a minimum operational life of 5000 hours.

### Pitot Static System

Pitot Static Head. The pitot static head is supported by a boom which is installed in the nose of the radome. It supplies both impact and static air pressure to the CADC and the airspeed/mach indicator. The altimeter and vertical velocity indicator receive only static pressure from the system.

The pitot head contains an anti-ice electrical heater which is controlled from a switch on the right vertical panel. It also has a lightning protection system consisting of an isolation transformer and special high voltage wiring. High voltage disconnects on the wiring are provided to facilitate installation and removal of the radome.

Pressure Altimeter. The AAU-7A/A altimeter, Figure 4-71, is an aneroid type which senses and indicates uncorrected pressure altitude based on static pressure inputs from the pitot static system. A setting knob at the lower left of the instrument face adjusts the altimeter setting and altitude indications. Altimeter indications are accurate to plus or minus 75 feet. Airfield barometric pressure is set into the altimeter during preflight. The instrument is integrally white lighted.

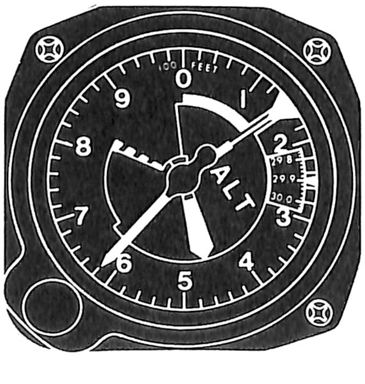


FIGURE 4-71. PRESSURE ALTIMETER

Complete provisions are included in the airplane for an optional AAU-19/A servoed altimeter. When the AAU-19/A is installed, its data is derived from the CADC which is the source of the automatic altitude reporting information transmitted via the AN/APX-72 IFF/SIF system. In this manner the cockpit altimeter indicates corrected pressure altitude as computed by the CADC.

Airspeed/Mach Indicator. The AVU-8B/A airspeed/mach indicator, Figure 4-72, indicates airspeed in knots from 80 to 850 and mach number from 0.5 to 2.2. The indicator is driven by the pitot static system. A maximum allowable airspeed pointer and an index setting pointer are included. The setting pointer is controlled between 100 and 700 knots by the SET INDEX knob. The indicator is integrally white lighted.

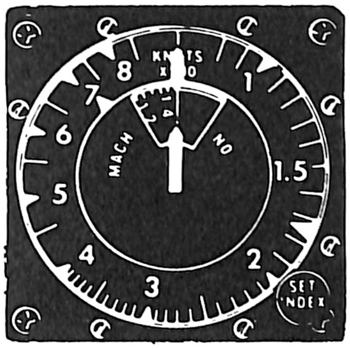


FIGURE 4-72. AIRSPEED/MACH INDICATOR

Vertical Velocity Indicator. The AAU-18/A vertical velocity indicator, Figure 4-73, operates only from static pressure received from the pitot static system. It indicates vertical velocity, up or down, from zero to six thousand feet per minute. The indicator is integrally white lighted.

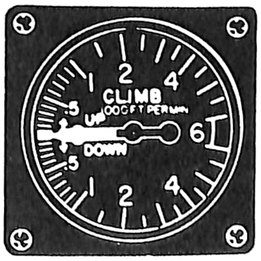


FIGURE 4-73. VERTICAL VELOCITY INDICATOR

## Angle-of-Attack System

The angle-of-attack (AOA) system in the F-5E is provided primarily to furnish the pilot with optimum landing approach angle-of-attack indication irrespective of aircraft gross weight and center of gravity location. The system also provides angle-of-attack information (corrected by the CADC) to the lead computing optical sight.

The F-5F employs an expanded capability AOA system which furnishes the pilots with optimum landing approach AOA and, in addition, provides optimum sustained turn AOA indication for student familiarization.

The system consists of a 14-64912 two-inch, hermetically sealed indicator, an MS 27582 indexer and a vane type transmitter with outputs to the indicator and the CADC. The indicator is located in the left instrument panel (both cockpits in the F-5F). The indexer is mounted above the glare shield (both cockpits in the F-5F), and the transmitter is located on the right side of the fuselage as shown in Figure 4-74. The vane contains an electrical heating element, powered by the left AC bus which is activated when the pitot anti-ice switch is turned on.

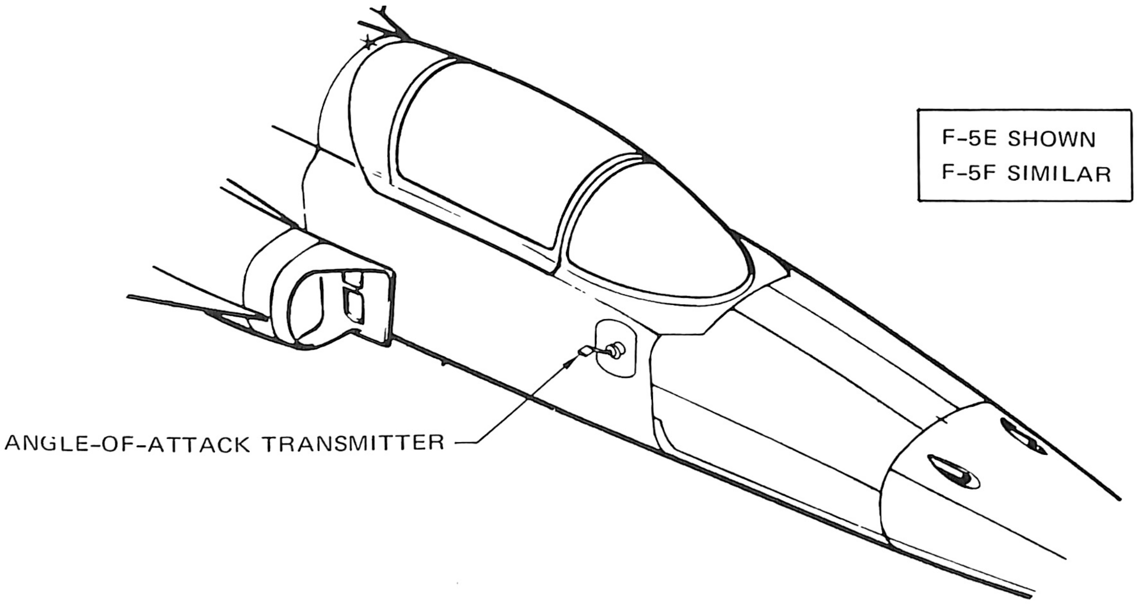
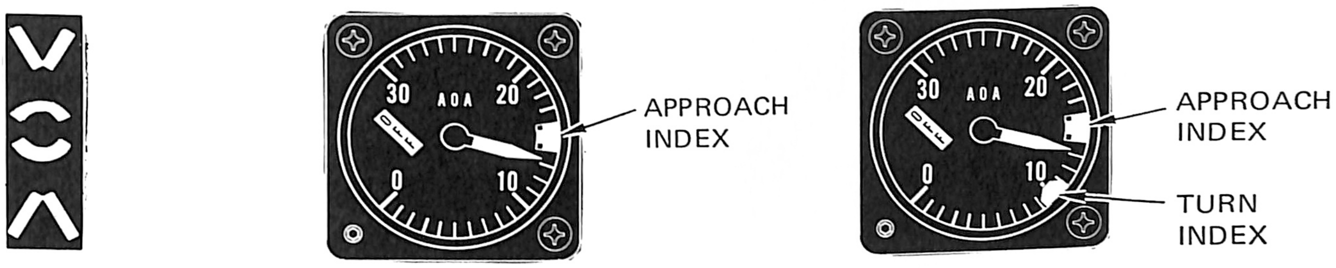


FIGURE 4-74. F-5E/F ANGLE-OF-ATTACK TRANSMITTER

The landing approach index on the indicators, Figure 4-75, and the indexer display are calibrated for the landing gear and flaps down landing configuration. This calibration is applicable to all stores configurations, both with wings level and during turning flight. The true angle-of-attack output from the CADC is calibrated for both the clean (launcher rails), and basic mission (launcher rails and missiles) configurations. The F-5F indicators have an added turn index mark which indicates the optimum AOA for maximum sustained turns at 0.9 mach number at 25,000 feet for the cruise flap setting with missiles or launcher rails.



INDEXER
(F-5E/F)

INDICATOR
(F-5E)

INDICATOR
(F-5F BOTH COCKPITS)

FIGURE 4-75. ANGLE-OF-ATTACK INDEXER AND INDICATORS

The indexer is illuminated by three lamps energized by solid-state switches in the indicator and indicates optimum angle-of-attack and deviations from optimum in both the high and low directions as shown in Figure 4-76. Separately, the three lamps indicate high (upper lamp), optimum (center lamp) and low (bottom lamp) angle-of-attack. Intermediate indications are obtained by simultaneously energizing two lamps. Illumination of the upper and center lights indicate slightly high angle-of-attack, and illumination of the center and bottom lamps indicates slightly low angle-of-attack. In both the F-5E and F-5F aircraft, the indexer is illuminated when the landing gear is extended and goes off when the gear is retracted. In the F-5F only, the AOA indexer can also be operated with the landing gear retracted by momentarily pressing the AOA MANUV toggle switch located outboard of the throttles (both cockpits).

F-5F AOA system consists of a 14-64912-5 front cockpit indicator, a 14-64912-7 rear cockpit indicator, two MS25317-8 indexers, and a TRU-180 transmitter.

The front cockpit indicator has switches to provide indexer commands for optimum AOA during landing approach. This indicator drives both front and rear indexers when the landing gear is down. The rear indicator has switches to provide indexer commands for maximum rate of turn at 0.9 Mach.

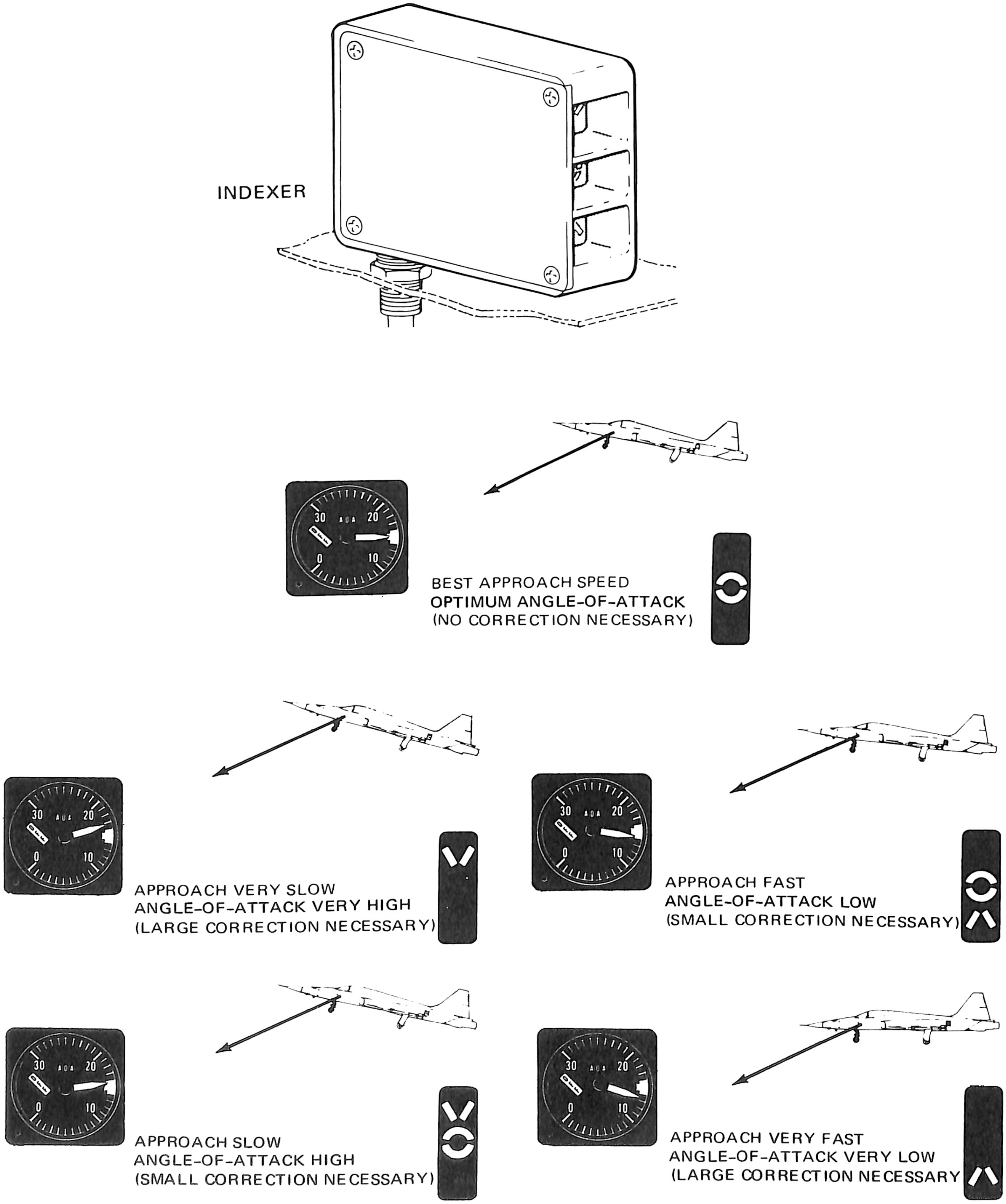

INDEXER
30
AOA
20
0
10
BEST APPROACH SPEED
OPTIMUM ANGLE-OF-ATTACK
(NO CORRECTION NECESSARY)
APPROACH VERY SLOW
ANGLE-OF-ATTACK VERY HIGH
(LARGE CORRECTION NECESSARY)
APPROACH FAST
ANGLE-OF-ATTACK LOW
(SMALL CORRECTION NECESSARY)
APPROACH SLOW
ANGLE-OF-ATTACK HIGH
(SMALL CORRECTION NECESSARY)
APPROACH VERY FAST
ANGLE-OF-ATTACK VERY LOW
(LARGE CORRECTION NECESSARY

FIGURE 4-76. LANDING APPROACH INDICATION

The rear indicator drives both the front and rear indexers when the landing gear is up. It is necessary for either front or rear seat pilot to actuate the AOA Maneuver switch to the ON position in order for the indexer lights to operate in this mode. Either pilot can turn off the indexer when in the maneuvering mode. The indexer lights are energized automatically when the landing gear is down to display the landing approach. Indexer dimming may be accomplished from the front cockpit only. The indexer may be tested from either cockpit.

The MTBF of the angle-of-attack system is estimated to be 1000 hours. To facilitate maintenance of the system, removal of the vane transmitter is accomplished from the exterior of the aircraft and dowel pin indexing is provided to allow reinstallation or replacement without recalibration.

## FIRE CONTROL SYSTEM

The F-5E/F fire control system accomplishes target detection and range tracking, lead computation for guns, in-range launch envelope computation for missiles, and provides a roll stabilized manually depressible aiming reference for the use of guns, bombs and rockets against ground targets. The fire control system consists of a fire control radar (FCR) and a lead computing optical sight system (LCOSS). The missile in-range envelope computations are performed by the LCOSS computer. Figure 4-77 is a block diagram of the F-5E system showing inputs from other systems and displayed outputs.

The F-5F fire control system consists of an FCR and LCOSS which is functionally identical to the F-5E system. Control of the FCR is possible from either cockpit but control of the LCOSS is available in the front cockpit only since there is no optical display unit in the rear cockpit. Initiation of the dogfight mode is possible from either cockpit.

Figure 4-78 is a block diagram of the F-5F system showing inputs from other systems and displayed outputs.

The discussion of the FCR operating modes and physical installations which follows will first describe the F-5E FCR (pages 4-119 through 4-124). Since the F-5F FCR is functionally identical, the description of the F-5F operation and installation will only address differences from the F-5E system (pages 4-125 through 4-127).

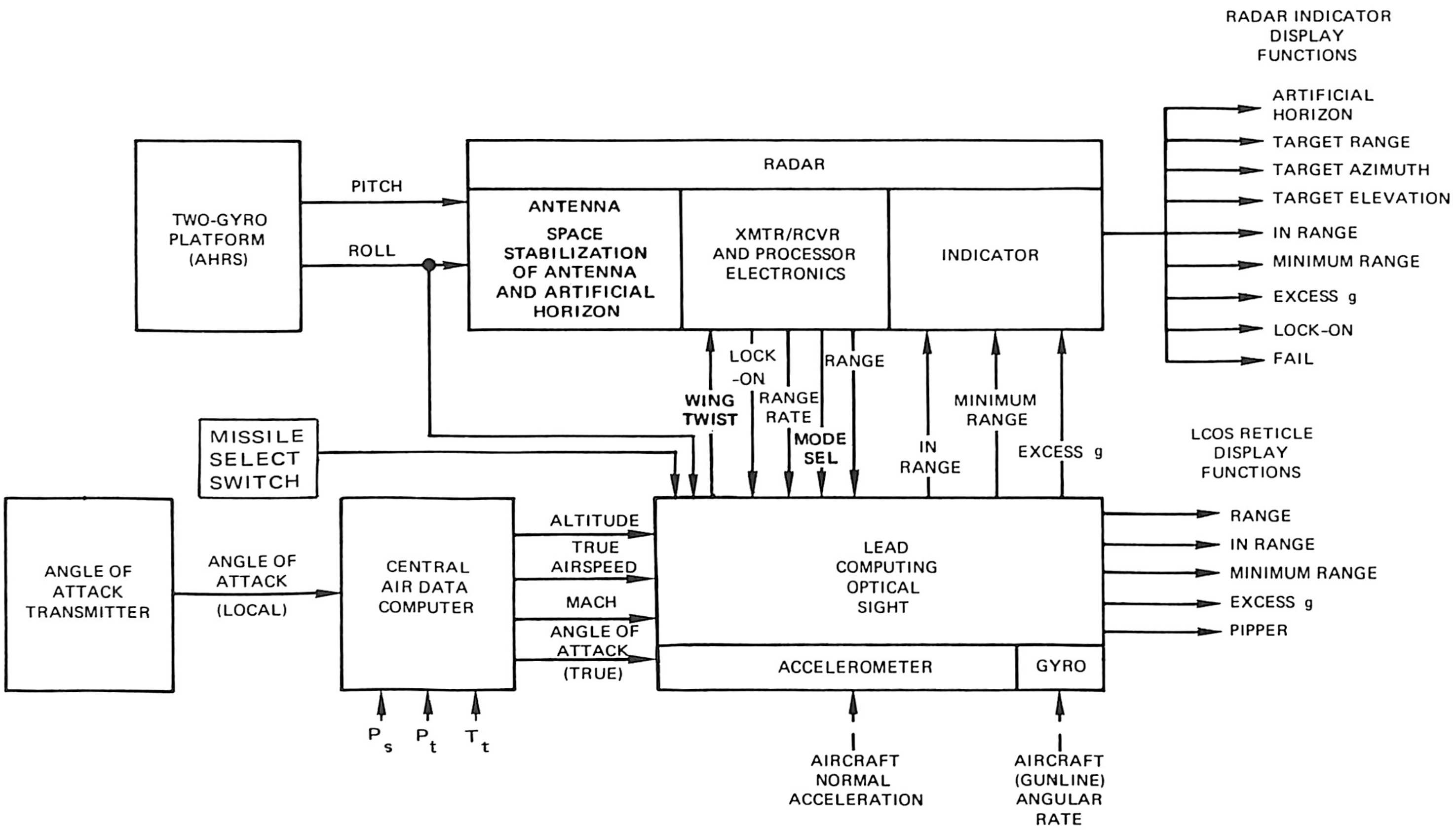

RADAR INDICATOR DISPLAY FUNCTIONS
ARTIFICIAL HORIZON
TARGET RANGE
TARGET AZIMUTH
TARGET ELEVATION
IN RANGE
MINIMUM RANGE
EXCESS g
LOCK-ON
FAIL
TWO-GYRO PLATFORM (AHRS)
PITCH
ROLL
RADAR
ANTENNA
SPACE STABILIZATION OF ANTENNA AND ARTIFICIAL HORIZON
XMTR/RCVR AND PROCESSOR ELECTRONICS
INDICATOR
LOCK -ON
RANGE
WING TWIST
RANGE RATE
MODE SEL
MINIMUM RANGE
IN RANGE
EXCESS g
MISSILE SELECT SWITCH
LCOS RETICLE DISPLAY FUNCTIONS
ANGLE OF ATTACK TRANSMITTER
ANGLE OF ATTACK (LOCAL)
CENTRAL AIR DATA COMPUTER
ALTITUDE
TRUE AIRSPEED
MACH
ANGLE OF ATTACK (TRUE)
LEAD COMPUTING OPTICAL SIGHT
ACCELEROMETER
GYRO
RANGE
IN RANGE
MINIMUM RANGE
EXCESS g
PIPPER
$P_s$ $P_t$ $T_t$
AIRCRAFT NORMAL ACCELERATION
AIRCRAFT (GUNLINE) ANGULAR RATE

FIGURE 4-77. F-5E FIRE CONTROL SYSTEM DIAGRAM

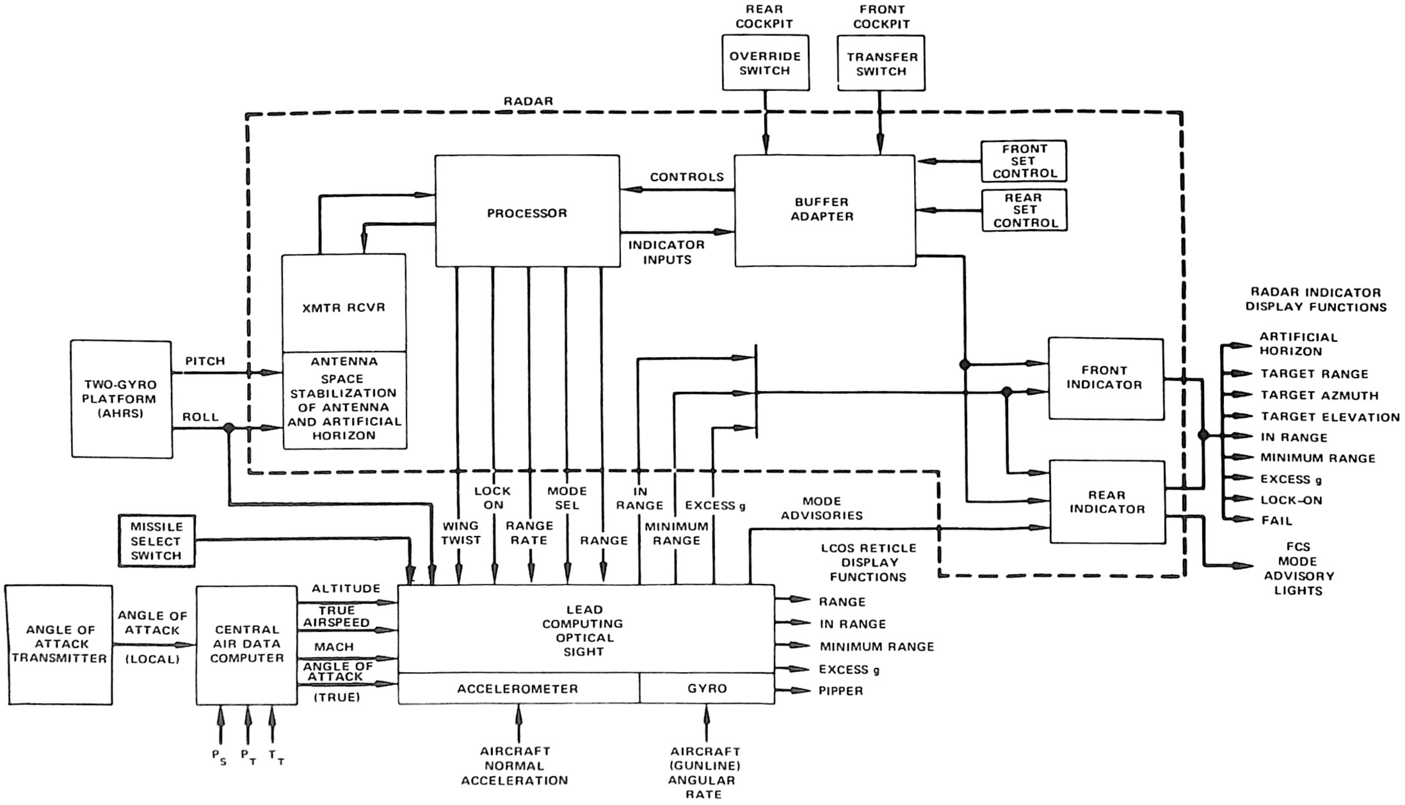

REAR COCKPIT
FRONT COCKPIT
OVERRIDE SWITCH
TRANSFER SWITCH
RADAR
PROCESSOR
CONTROLS
BUFFER ADAPTER
FRONT SET CONTROL
REAR SET CONTROL
INDICATOR INPUTS
XMTR RCVR
ANTENNA SPACE STABILIZATION OF ANTENNA AND ARTIFICIAL HORIZON
TWO-GYRO PLATFORM (AHRS)
PITCH
ROLL
RADAR INDICATOR DISPLAY FUNCTIONS
ARTIFICIAL HORIZON
TARGET RANGE
TARGET AZIMUTH
TARGET ELEVATION
IN RANGE
MINIMUM RANGE
EXCESS g
LOCK-ON
FAIL
FCS MODE ADVISORY LIGHTS
FRONT INDICATOR
REAR INDICATOR
LOCK ON
MODE SEL
IN RANGE
EXCESS g
MODE ADVISORIES
WING TWIST
RANGE RATE
RANGE
MINIMUM RANGE
MISSILE SELECT SWITCH
LCOS RETICLE DISPLAY FUNCTIONS
ANGLE OF ATTACK TRANSMITTER
ANGLE OF ATTACK (LOCAL)
CENTRAL AIR DATA COMPUTER
ALTITUDE
TRUE AIRSPEED
MACH
ANGLE OF ATTACK (TRUE)
LEAD COMPUTING OPTICAL SIGHT
ACCELEROMETER
GYRO
RANGE
IN RANGE
MINIMUM RANGE
EXCESS g
PIPPER
$P_S$ $P_T$ $T_T$
AIRCRAFT NORMAL ACCELERATION
AIRCRAFT (GUNLINE) ANGULAR RATE

FIGURE 4-78. F-5F FIRE CONTROL SYSTEM DIAGRAM

## Fire Control Radar, F-5E

The F-5E employs a lightweight AN/APQ-153 X-band air-to-air search and range-tracking FCR. The radar design is third generation electronics state of the art making extensive use of microminiature integrated circuits and solid state devices. The system modes of operation are: standby, search, missile, guns, and test.

Standby Mode. The standby mode is a nonradiating warm-up mode. The warm-up time is three to five minutes depending on the cold soak condition. This mode is selected by placing the mode switch on the set control, shown in Figure 4-82, in the STBY position.

Search Mode. The search mode is selected by placing the mode switch in the OPER position. In this mode the transmitter/receiver is radiating and the antenna scans a two-bar, 10-degree elevation, 90-degree azimuth pattern as shown in Figure 4-79.

The scan pattern may be tilted in elevation to 45 degrees above or below the armament datum line (ADL), and is stabilized in pitch and roll so that the pattern, once placed, will stay in the same pitch and roll orientation. Display range scales of

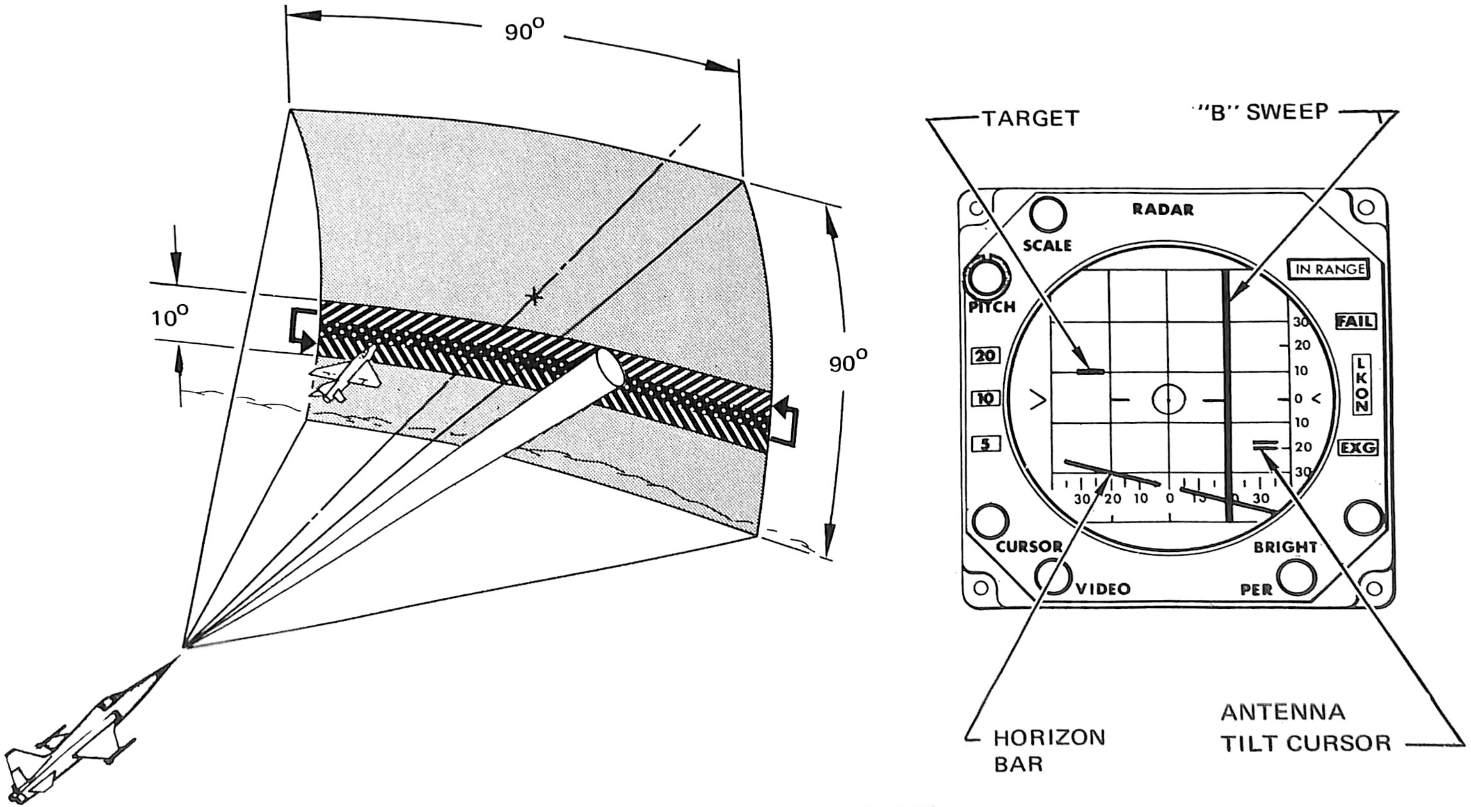

90°
10°
90°
TARGET
"B" SWEEP
RADAR
SCALE
IN RANGE
PITCH
20
10
5
FAIL
LK ON
EXG
30
20
10
0
10
20
30
30 20 10 0 10 20 30
CURSOR
VIDEO
BRIGHT
PER
HORIZON BAR
ANTENNA TILT CURSOR

FIGURE 4-79. SEARCH MODE

five, ten or twenty nautical miles are selectable on the set control. This sets the display scale such that the top range (horizontal) line indicates the maximum range of the selected scale, i.e., five, ten or twenty nautical miles. The bottom line indicates zero range and the other range lines divide the range scale into five equal increments. The target relative azimuth and elevation angles can also be determined from the display. The horizontal position of the target in the display indicates the relative azimuth angle which is read on the bottom scale. The target elevation angle relative to the ADL is determined from the position of the antenna tilt cursor which approximates the target elevation angle (the target is within the 10-degree, 2-bar sweep). The antenna tilt angle is read on the vertical scale at the right. The pitch and roll attitude of the aircraft is also indicated on the display by the position of the horizon bar.

Missile Mode. When a target is detected and ranging information is desired for missiles, the pilot flies the aircraft to cause the target to appear on the vertical centerline of the scope and the tilt cursor to move to zero degrees in elevation. Missile ranging (missile mode) may now be initiated by positioning the LCOSS mode switch to MSL and pushing the ACQ (acquisition) button on the radar set control. This causes the antenna to boresight on the missile reference line and the range gate to start slewing from 500 feet outward to 5 or 10 miles depending on the scale selected on the radar set control. The slewing is rapid, taking only three seconds to complete the cycle. After the button is released, the range gate will continue slewing until it locks on the first adequate target. If this is not the desired target, it may be rejected by pushing the ACQ button again which reinitiates range gate slewing. With target lock-on, range and range rate information is fed to the LCOSS and the radar antenna starts to conically scan about the ADL allowing the radar processor to extract steering information. The display of steering is a steering bar which shows relative position of the target in azimuth and elevation. This allows the pilot to fly the aircraft to position the bar in the steering circle which is equivalent to the missile field of view as shown in Figure 4-80. The steering bar is biased to compensate for wing twist to retain the target in the missile field of view with the steering bar in the steering circle. The vertical position of the actual target blip on the "B" sweep in the center of the radar indicator display indicates the target range in the same manner as previously described for the search mode. The sight system will then solve the missile in-range and excess-g equations. With the steering bar in the circle, a missile tone in the pilot's headset, IN RANGE light and no EXG (excess-g) light, a missile may be launched.

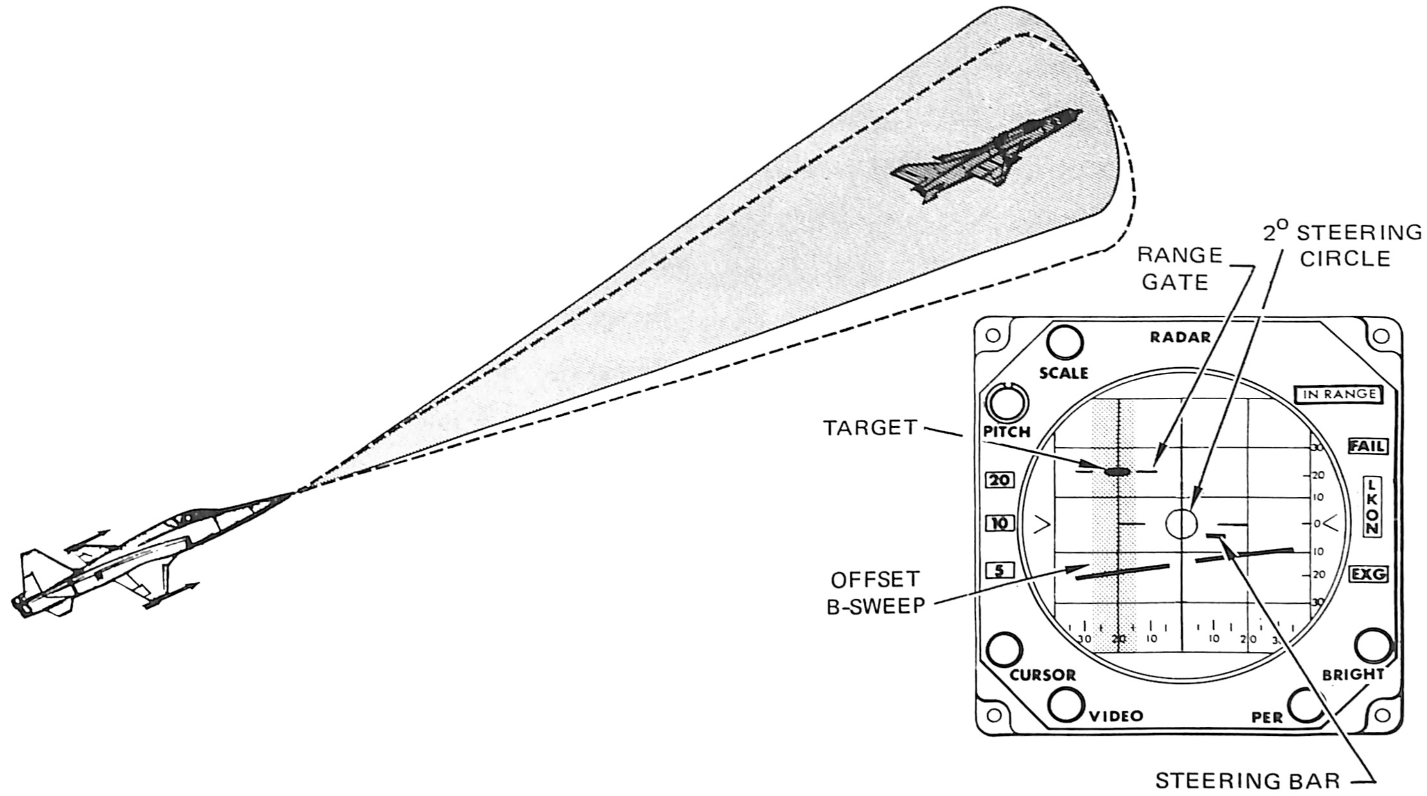

2° STEERING CIRCLE
RANGE GATE
RADAR
SCALE
IN RANGE
TARGET
PITCH
FAIL
20
10
5
LKON
EXG
OFFSET B-SWEEP
30
20
10
0
10
20
30
CURSOR
BRIGHT
VIDEO
PER
STEERING BAR

FIGURE 4-80. MISSILE MODE

Guns Mode. The radar is placed into the air-to-air gunnery mode against maneuvering targets from the missile mode by selecting A/A1 (LCOSS maneuvering target mode) on the LCOSS optical display unit or by pressing the dogfight button on the control stick. This preempts all other radar and LCOSS modes of operation and places the LCOSS in the A/A1 mode regardless of LCOSS mode selection. To release the system from this mode, the RESUME SEARCH button on the radar set control is pressed.

The system is placed in the air-to-air guns mode against nonmaneuvering targets by selecting A/A2 on the LCOSS optical display unit.

To place the radar into the guns mode directly from the search mode, the procedures are the same as described above except that after selecting either A/A1 or A/A2 on the LCOSS, the ACQ button must be depressed on the radar set control. Selection of the guns mode by any of the above methods causes the radar antenna to move to a boresight position 2.0 degrees below the ADL at zero azimuth. This antenna position will allow radar range tracking at elevation lead angles up to 11 degrees. When the antenna reaches the gun mode boresight position and the radar was not locked on to a target at a range of 5600 feet or less in the missile mode, the range gate begins slewing from 500 feet out to 5600 feet at 0.3 second intervals and will continue slewing after the ACQ or dogfight button is released until the range gate locks on to the first adequate target. If the pilot determines that he is locked on to the wrong target, he may reject it by again pressing the ACQ button, if the guns mode was entered by any of the above methods, or the dogfight button, only if the mode was actuated by the dogfight button, which then reinitiates range gate slewing. If the radar was locked on to a target at a range of 5600 feet or less in the missile mode, the lock-on will not be broken when the system is switched to the guns mode. After lock-on, range and range rate are provided to the LCOSS for target lead angle computation. In the guns mode the pilot flies head up using the LCOSS display and need not refer to the radar display.

Test Mode. The test mode is selected by placing the mode switch on the set control in the TEST position any time after the system is warmed up. In this mode a calibrated test signal is injected into the receiver to simulate a target at 2000 feet, and a check is automatically made of the receiver lock-on sensitivity and range accuracy by activating missile acquisition. An out-of-tolerance condition is indicated by illumination of the FAIL light on the indicator.

System Performance. The radar system performance and accuracy is as follows:

1. In an uncluttered environment the air-to-air detection range is greater than 8 nautical miles when closing at a rate of 1000 feet per second on a 2-square-meter fluctuating target with a cumulative probability of 85 percent. This is equivalent to a range of 18 nautical miles with a 50-square-meter target.
2. Adaptive fast time constant circuits, range programmed baseline clipping, and manually adjustable video clipping are provided to yield optimum detection and lock-on ranges at all altitudes and clutter environments.
3. The air-to-air lock-on range in an uncluttered environment exceeds 6 nautical miles minimum on a 2-square-meter target. Lock-on capability is provided from 10 nautical miles to 500 feet. Lock-on is possible almost immediately after detection.
4. Steering accuracy of ±1 degree is displayed for missile launching.
5. Automatic air-to-air range tracking accuracy is ±50 feet from 500 to 1000 feet, ±30 feet from 1000 to 2000 feet, and 2 percent of range out to 10 nautical miles for gun and missile attacks. These are standard deviation values.

6. In the course of the F-5E flight test program, the fire control radar has detected a co-altitude T-38 target aircraft (approximately two square meters radar cross section) at a range of 12 nautical miles from a test altitude of 27, 500 feet above ground level (AGL). At an altitude of 17, 500 feet both detection and lock-on were accomplished at a range of 10 nautical miles, the maximum range at which mechanization of the radar permits lock-on. The radar has consistently demonstrated an ability to lock on to a T-38 aircraft in the tail aspect out to the maximum gun mode lock-on range of 5600 ±400 feet at altitudes down to 1800 feet AGL. Detection and lock-on at 40, 000 feet AGL against an F-104 target has occurred at a range of nine nautical miles. Large targets such as F-4's have been detected at ranges up to 19 nautical miles.

Line Replaceable Units. The radar system consists of an antenna assembly, transmitter/receiver, radar processor, indicator, and set control. The system is designed to eliminate flightline adjustments. Each assembly is a line replaceable unit (LRU) which is independently calibrated. Individual LRU's are of modular construction to the maximum extent, and the majority of the modules can be calibrated for replacement in the LRU without further adjustment. This design concept permits a system mean-time-to-repair (MTTR) of sixty minutes on the flightline and two hours at the intermediate (field shop) level. The system design provides continuous failure monitoring of transmitter power, low voltage power, and AFC error voltage. LRU fault isolation is accomplished through the use of flightline AGE. The radar system mean-time-before-failure (MTBF) is specified as 75 hours with a minimum acceptable MTBF of 50 hours and a predicted MTBF to be 280 hours based on a piece part count and the use of procedures prescribed in MIL-HDBK-217.

The antenna assembly, AS-2736/APQ-153, consists of a 12 x 16-inch parabolic antenna, two-axis gimbals, direct drive dc torque motors and a lightweight cast base. The antenna is a horizontally polarized, parabolic dish with an elliptical outline and center ring focus feed. Preboresighting of the antenna with reference to the attach point plane allows interchangeability of antenna assemblies without postinstallation boresighting.

The transmitter/receiver assembly, RT-1059/APQ-153, includes the magnetron, modulator, AFC, preamplifier, local oscillator, microwave components (mixers, isolator, TR tubes and circulator), and desiccator. The design of the transmitter/

receiver assembly, and the environmental characteristics of the electronic components selected for it, permit the assembly to be hard mounted on the right side of the nose just aft of Fuselage Station 90 where it will operate satisfactorily in the gunfiring vibration environment.

The radar processor, MX-9151/APQ-153, contains the circuitry to process the incoming video information from the receiver preamplifier and convert it into range and range rate information for use by the LCOSS. Additionally, it contains the antenna servo drive assemblies, search programmer, indicator auxiliary circuits, lock-on detector, low voltage power supplies, dc voltage regulator circuits, and amplifier. The processor is hard mounted on the left side of the nose just aft of Fuselage Station 90.

The indicator, IP-1099/APQ-153, shown in Figure 4-81, is mounted in the instrument panel directly in front of the pilot. It consists of a 5-inch direct-view storage tube with its high-voltage power supply, and controls for adjusting the display. The controls consists of a SCALE knob for adjusting the intensity of the range scale lights, a PITCH knob for trimming the artificial horizon, a CURSOR knob for adjusting the light intensity of the tilt cursor symbol and artificial horizon line, a BRIGHT knob for adjusting the light intensity of the tube background, a PER knob for adjusting persistence and a VIDEO knob for adjusting video gain (contrast). In addition to the storage

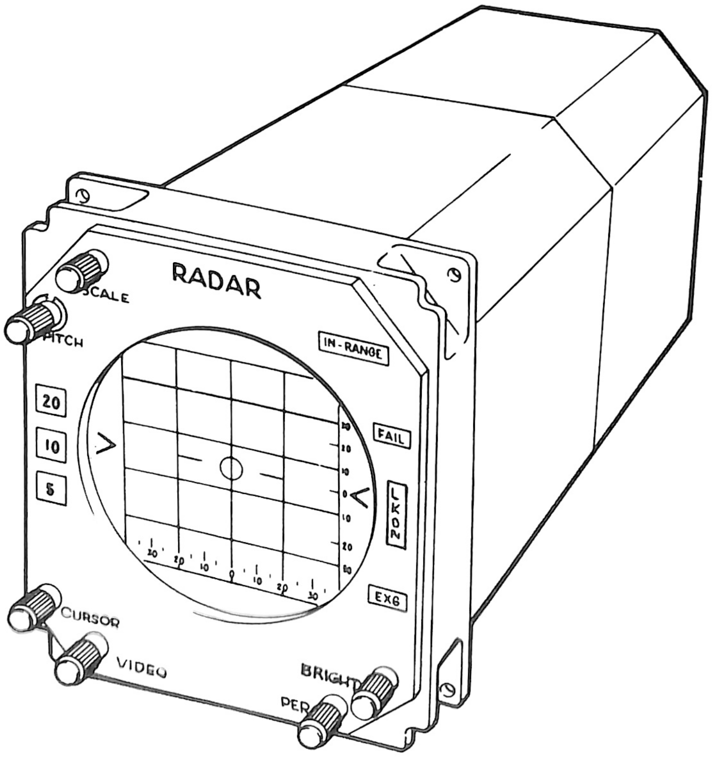


FIGURE 4-81. F-5E RADAR INDICATOR

tube display controls, there are three range scale lights (5, 10 and 20 nautical miles), a LK-ON indicator which lights to indicate radar lock-on, and IN-RANGE light which glows steadily when a target is in range and flashes when target range is less than minimum, a FAIL light which is activated by the failure monitoring and test circuits, and an EXG light indicating excess g conditions for missile launch. The tube has a circularly polarized overlay to reduce reflection and a dynamic intensity range which allows day or night operation.

The set control, C-8978/APX-153, includes the antenna elevation control, range scale selector, mode selector, acquisition button and a resume search button as shown in Figure 4-82.

The antenna control is contoured so that the hand and fingers will be positioned naturally for operation. The set control is mounted in the left-hand console directly aft of the power control.

### Fire Control Radar, F-5F

The F-5F utilizes the AN/APQ-157 radar which is the F-5E AN/APQ-153 radar modified and augmented to accommodate the requirements of the F-5F but maintaining the performance and essential characteristics of the F-5E system. It provides for radar control and display in both cockpits. Control of the radar and some indicator controls are transferable between cockpits by means of the radar transfer switch in the front cockpit or the radar override switch in the rear cockpit. The radar override switch will cause control to be transferred to the rear cockpit regardless of the position of the front cockpit transfer switch. The controls which are transferable are listed below. When transferred, they provide the capability to control the specific functions noted from the cockpit to which transfer has been made. The Radar Set Control, found in both cockpits of the F-5F, is shown in Figure 4-82.

Transferable Set Control Functions

Mode Select (Off, Standby, Operate, Test)
Acquisition
Resume Search
Antenna Tilt
Range Selection

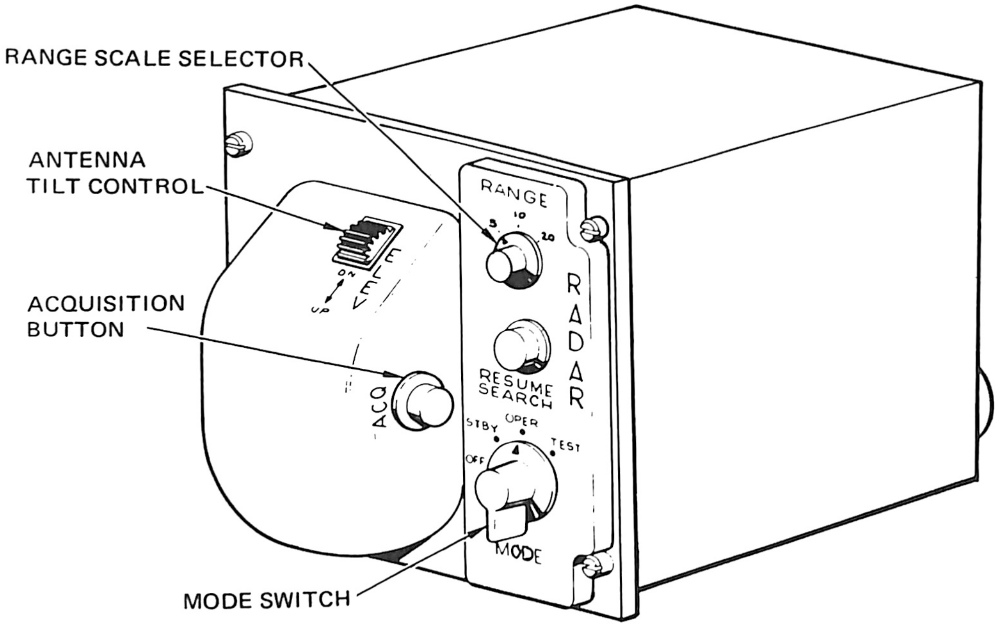

RANGE SCALE SELECTOR
ANTENNA TILT CONTROL
ACQUISITION BUTTON
MODE SWITCH
RANGE
5
10
20
ELEV
ON
UP
ACQ
RADAR
RESUME SEARCH
STBY
OPER
TEST
OFF
MODE

FIGURE 4-82. F-5E/F RADAR SET CONTROL

Transferable Indicator Control Functions

Video

Pitch Trim

Brightness, persistence, cursor, and scale controls on each indicator are not transferable because they are for individual display control. Control of the LCOSS is possible from the front cockpit only. The dogfight mode can be initiated from either cockpit.

The system design provides close correlation of the simultaneous displays on the front and rear indicators in order to assure the high degree of correspondence between displays required for the training mission. The system modes of operation of the radar in the F-5F are the same as in the F-5E: Standby, Search, Missile, Guns, and Test.

Standby Mode. The standby mode is selected by placing the mode switch (shown in Figure 4-82) in the STBY position, on the set control in the cockpit to which control has been transferred.

Search Mode. The search mode is selected by placing the mode switch in the OPER position on the set control in the cockpit to which control has been transferred.

Missile Mode. Missile ranging (missile mode) is initiated by positioning the LCOSS mode switch (Figure 4-84) to MSL (front cockpit only) and pushing the ACQ (acquisition button on the radar set control in the cockpit to which control has been transferred.

Guns Mode. The radar is placed in the air-to-air gunnery mode against maneuvering targets from the missile mode by selecting AA-1 (LCOSS maneuvering target mode) on the LCOSS optical display unit (front cockpit only) or by pressing the dogfight button on the control stick in either cockpit. To release the system from this mode, the RESUME SEARCH button is pressed on the radar set control in the cockpit to which control has been transferred.

The system is placed in the air-to-air mode against nonmaneuvering targets by selecting AA-2 on the LCOSS optical display unit (front cockpit only).

To place the radar in the guns mode directly from the search mode, the procedures are the same as described above except that after selecting either AA-1 or AA-2 on the LCOSS, the ACQ button must be depressed on the radar set control in the cockpit to which control has been transferred.

Test Mode. The test mode is selected by placing the mode switch, on the set control in the cockpit to which control is transferred, in the TEST position any time after the system is warmed up.

Line Replaceable Units. The F-5F radar system consists of an antenna assembly, transmitter/receiver, radar processor, buffer adapter, front indicator, rear indicator, front set control and rear set control. The system is designed to minimize the number of flight line adjustments. Each assembly is a line replaceable unit (LRU) which is individually calibrated.

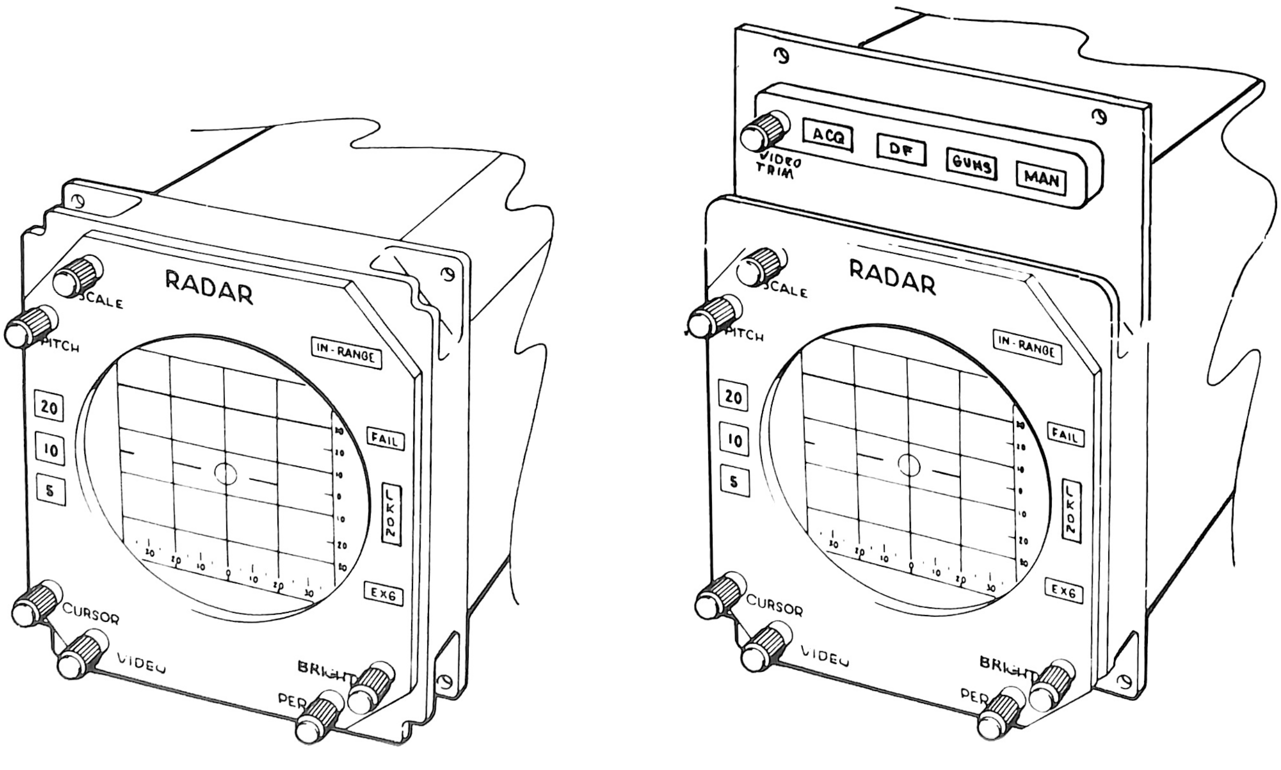
The AS-2736/APQ-153 antenna assembly and the RT-1059/APQ-153 transmitter/receiver assembly are identical to the F-5E. The MX-9151/APQ-153 radar processor is the basic F-5E LRU with minor modifications required for the F-5F application.

The buffer adapter, an F-5F peculiar LRU, contains the electronics necessary to interface the second indicator and rear set control with the other LRU's of the radar system. It interfaces all power to the indicators originating in the processor LRU except for +30 vdc and -5 vdc (unregulated) which are provided by the buffer adapter internal dc supply to the rear indicator. The buffer adapter also contains the logic for transferring of radar control between front and rear set controls as well as providing for transfer of video, and pitch trim controls between front and rear indicators. The LRU is hard mounted to the center web in the left-hand forward avionics bay.

The front indicator, IP-1099/APQ-153 (Figure 4-83), is identical to the F-5E and is mounted in the instrument panel directly in front of the pilot. It consists of a 5-inch direct-view storage tube with its high-voltage power supply, and controls for adjusting the display.

The rear indicator, an F-5F peculiar LRU, also shown in Figure 4-82, is installed in the rear cockpit instrument panel and is functionally identical with the front indicator except that it contains four additional fire control system mode status advisory lights along the top. These indicate: actuation of the front cockpit acquisition switch (ACQ); initiation of the dogfight mode (DF); selection of the LCOSS guns mode GUNS); selection of the LCOSS manual mode (MAN).

The set control, C-8978/APQ-153, is identical to the F-5E, Figure 4-82. There is one set control installed in each cockpit. Both the front and rear set controls are mounted in the left-hand console directly aft of the throttles.



FRONT
COCKPIT

REAR
COCKPIT

FIGURE 4-83. F-5F RADAR INDICATORS

## Lead Computing Optical Sight System (LCOSS)

The F-5E/F LCOSS, AN/ASG-29, consists of an optical display unit (ODU) (Figure 4-84) installed in the upper center of the instrument panel and a gyro lead computer located in the aft electrical equipment bay. The system is supplied with data from the angle of attack system, the CADC, the two-gyro platform, and the fire control radar (FCR). The ODU in the F-5F is installed in and controlled from the front cockpit only, but operation and performance is identical to the F-5E system.

The LCOSS provides four modes of operation: air-to-air guns (A/A1) against maneuvering targets, air-to-air guns (A/A2) against nonmaneuvering targets, air-to-air missiles (MSL) and a manual mode (MAN) for air-to-ground.

Missile Mode. In the air-to-air missile mode the LCOSS pipper corresponds to the missile reference line, thus providing an aiming reference for missile firing. The position of the pipper is biased in this mode to compensate for wing twist to retain the target in the missile field of view when the pipper is on the target. The LCOSS and FCR are placed in the missile mode by positioning the LCOSS mode selector switch, shown in Figure 4-83, to MSL and depressing the ACQ button on the radar and set control. With FCR lock-on, radar range to the target is displayed on the inside of the 50 mil diameter ring of the reticle display (Figure 4-84), from 60,000 feet at the 6 o'clock position to 500 feet (minimum radar range) between the twelve and one o'clock positions. In-range (diamond), minimum range (circle) and excess g's (rectangle) indications are displayed based on AIM 9-B, E or J missile launch condition envelope computations performed by the gyro lead computer unit utilizing range and range rate inputs from the FCR, and altitude and Mach number functions from the CADC, as well as 'g' from the LCOSS. Loss of FCR lock-on will cause loss of range and excess-g information from the sight reticle display.

Air-to-Air Guns Mode. In an air-to-air gunnery attack, the system provides the capability for using two aiming techniques, snapshoot and tracking. The snapshoot technique is used only in the A/A1 (maneuvering target) mode. This technique does not require target tracking. In this mode, the pipper position is the impact point of a projectile at target range which has been fired one time-of-flight earlier. The pilot fires one time-of-flight prior to the time it is anticipated that the pipper will cross the target.

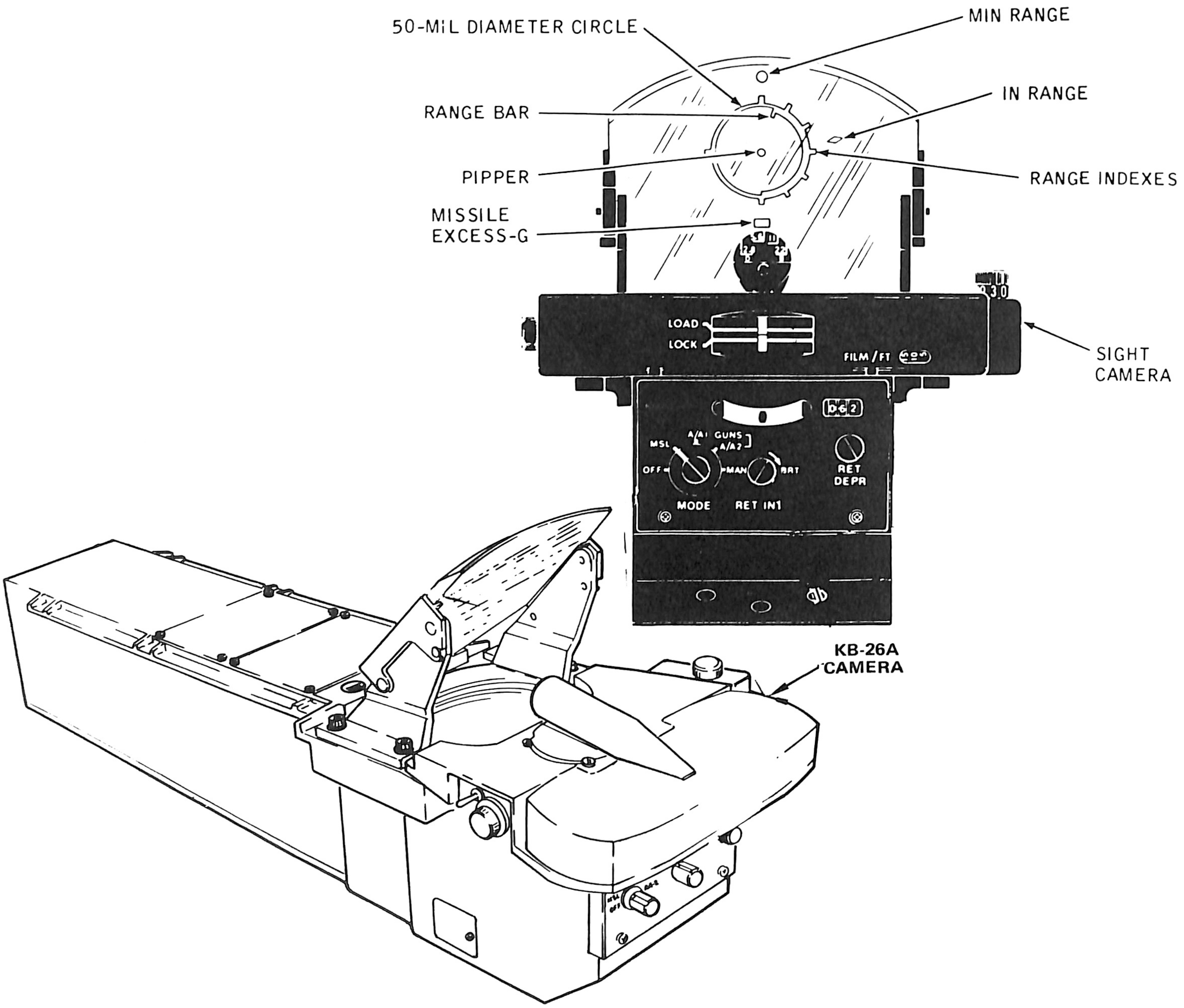

50-MIL DIAMETER CIRCLE
MIN RANGE
RANGE BAR
IN RANGE
PIPPER
RANGE INDEXES
MISSILE EXCESS-G
SIGHT CAMERA
LOAD
LOCK
FILM/FT
062
MSL
A/A1
GUNS
A/A2
OFF
MAN
BRT
RET DEPR
MODE
RET IN1
KB-26A CAMERA

FIGURE 4-84. F-5E/F OPTICAL DISPLAY UNIT

The tracking technique provides higher kill probability for the A/A2 (nonmaneuvering target) mode and may also be used in the A/A1 mode. In this technique the pilot flies his aircraft so that the pipper tracks and is superimposed upon the target for approximately one second prior to the time of firing.

Lead angle computations for both gun modes are based on turn rate and acceleration signals measured in the gyro lead computer, target range and range rate provided by the FCR and altitude, airspeed, and angle-of-attack information from the CADC. In addition to the range information provided by the FCR, fixed range values are utilized for computation as subsequently described for each mode.

To place the fire control system into either the A/A1 or A/A2 mode, the LCOSS mode selector switch on the optical display unit is positioned at A/A1 or A/A2. Pressing the dogfight button on the stick (either cockpit in the F-5F) causes the system to enter the A/A1 mode regardless of LCOSS mode selection. In either of these modes, with FCR lock-on, the lead angle computation is based on radar range to a maximum range of 2700 feet. A fixed range of 2700 feet and actual range rate are used for computation beyond this range in order to provide an aim point not subject to excessive wander or large transients due to loss and reacquisition of FCR lock-on. The 2700-foot value was selected as it is the maximum range for effective gunfiring. Radar range to the target is displayed on the inside of the 50 mil diameter ring of the reticle display from 6000 feet at the six o'clock position to 500 feet (minimum radar range) between the twelve and one o'clock positions. At target ranges between 2700 feet and 1000 feet, the in-range indication is displayed. At a radar range of 1000 feet, the minimum range or breakaway indication appears and the in-range indication disappears. If radar range lock-on is lost, the range bar and in-range or minimum range light disappear from the reticle display and the sight computer will automatically revert to a 1500-foot range and a fixed overtake speed of 150 feet per second for lead angle computation.

Manual Mode. Manual mode is selected by placing the mode selector switch in the MAN position. In this mode, the LCOSS provides a roll stabilized manually depressible reticle (0 to 200 mils depression range) aiming reference for use of guns and delivery of bombs and rockets air-to-ground, or for air-to-air use as a backup in the event a sight failure prevents use of the normal air-to-air guns or missile modes. The roll stabilization feature allows bomb aiming from other than a wings-level attitude.

LCOSS Line Replaceable Units (LRU). The lead computing optical sight system consists of an optical display unit (ODU) LRU, a gyro lead computer LRU, and a gyro lead computer mounting base assembly. The ODU LRU is located in the upper center of the aircraft instrument panel; the gyro lead computer LRU and the mounting base are located in the aft electrical equipment bay.

The ODU, SU-68/ASG-29, contains the LCOSS controls, reticle and associated 4-inch optics. The pilot's aiming reference is projected onto a combining glass and the image collimated such that it appears to be superimposed on the target. The reticle excursion limits are 240 mils in elevation and 208 mils in azimuth. The reticle display is a brilliant aviation red in color and is visible against a 10,000-foot-lambert background. The ODU is preboresighted, and is installed without realignment. An edge-lighted control panel is mounted to the ODU. Light intensity is controlled by the console light control. At the left of the panel is the five-position mode selector switch for choice of weapon delivery mode. The reticle intensity control is located in the center of the panel. Directly above the reticle intensity control, a tube and ball slip indicator is provided. At the right side of the panel is the manual reticle depression control and a digital readout that will indicate reticle depression with a resolution of 1 mil.

The gyro lead computer unit, CN-1390/ASG-29, contains the gyroscope assembly, electronic modules and power supply. The electronic modules perform both the sight and missile in-range computation functions. The missile in-range computer function is physically and functionally integrated within the gyro lead computer. The gyro lead computer mount is hard mounted in the aft equipment bay and is factory aligned so that removal and replacement of the gyro lead computer can be accomplished without realignment. Selection of the proper missile-in-range computer input to match the missile being carried is made on the missile select switch. It is a three-position switch marked AIM-9B, AIM-9E, AIM-9J, and is located directly behind the pilot's seat. This setting is made on the ground and is an inspection item on the pilots preflight checklist.

Built-In-Test (BIT) is utilized to determine operational readiness of the LCOSS. With the airplane in static condition on the ground, the BIT procedure is performed by selecting BIT 1 or BIT 2 on the sight BIT switch located outboard of the radar set control (front cockpit only in the F-5F). BIT 1 position tests circuitry and hardware in the ODU and BIT 2 tests circuitry and hardware in the gyro lead computer. Go (diamond) and no-go (circle) indicators appear in the ODU display. The BIT procedure provides assurance that the LCOSS is able to function within defined operating limits with 90 percent confidence. Fault isolation to an LRU is also accomplished to a 90 percent confidence level. The LCOSS is designed for a minimum useful life of 3000 hours with an MTBF of 300 hours.

KB-26A Sight Camera. A KB-26A electrically-driven 16mm camera, shown in Figure 4-84, is mounted on the LCOSS ODU to photograph the sight reticle and target as viewed by the pilot during gun firing, missile launch, and external store release. The camera body, LB-38A, AERNO 74-0693, mounted to the sighthead with four bolts, is equipped with a reflecting periscope which captures the entire reticle picture and reflects it onto the film. The camera is equipped with a dual-pin pulldown mechanism and a dual-pin registration to ensure accurate film placement even in the high vibration environment normally encountered during gun firing. Mounting the camera directly to the ODU eliminates any requirements for camera boresighting.

The periscope is fitted with a manually-adjusted iris with f-stop indications, which may be set during flight to accommodate the ambient light conditions. Camera frame rate, either 24 or 48 frames per second, is set by a two-position switch on the side of the camera body.

The camera may be fitted with a standard magazine, LB-40A, AERNO 74-0692, having a capacity of 50 feet of 6-mil MS aerial film or 65 feet of thin base 4-mil film. The magazine is pin-registered to the camera body, and is instantly detachable without disturbing the camera body or electrical connections.

Camera operation is initiated when the pilot depresses the trigger on the control stick to the first of two detent positions. This action permits use of the camera prior to gunfiring or without gunfiring. Gunfiring is initiated by depressing the trigger (front cockpit only in the F-5F) to the second detent position. In this latter case, an internal dual-intensity light in the camera body is simultaneously energized to continuously mark the film edge at bright intensity during the entire period of gun firing. When the pilot releases the trigger the camera automatically switches to an "overrun" mode, and the intensity of the internal marking light is reduced to denote this condition. The duration of camera overrun is controlled by a knob on the camera body and may be set for 0, 3, 10, or 20 seconds after the end of gun firing.

For missile, bomb, and rocket firing coverage, the camera starts when the missile/bomb/rocket button is actuated, and continues to run for the period established by the setting of the overrun timer knob.

Additional details on camera control, and armament selection, are presented in the armament controls description starting on page 4-142.

The camera is specified to have a maximum failure rate of not more than one occurrence in 5000 feet of film, and is expected to have an operational service life of approximately 200,000 feet, equivalent to approximately 10 years use.

## ARMAMENT AND EXTERNAL STORES

### 20mm Gun Installation

The F-5E is equipped with two M-39 20mm guns and 560 rounds of ammunition. The F-5F has one M-39 20mm gun and 140 rounds of ammunition. Firing at the rate of 1500 rounds per minute per gun, more than 11 seconds of continuous fire at a combined rate of 3000 rounds per minute is provided for the F-5E and more than 5 seconds of continuous fire at 1500 rounds per minute for the F-5F. The M-39 gun is designed for a service life of 10,000 rounds, and the barrels require replacement every 1500 rounds for average burst lengths of one to three seconds. The M-39 guns in the F-5E (Figure 4-85) are mounted in the upper portion of the aircraft nose and are supported by a spring type forward mount to reduce recoil loads and a sliding rear mount to accommodate recoil motion. The rear mount is adjustable in elevation and azimuth. The guns are located high in the bay to simplify the feed system, facilitate maintenance, reduce ammunition loading time, and reduce engine ingestion of gun exhaust gases. The gun location eliminates any pitching moment due to gun firing. Deflector doors are positioned below each muzzle to deflect gun gases away from the engine inlets.

The single M-39 gun in the F-5F is mounted in the upper left portion of the aircraft nose. All F-5F gun mounting equipment is similar in configuration and location to the F-5E. The basic changes to the F-5E installation are in the ammunition box, feed chute, case ejection chute and link bay compartment. The ammunition box, except for depth and length, is similar to the F-5E construction. The ammunition feed and case ejection chutes are changed in length only. The link bay compartment is similar in construction to that employed on the F-5E, but smaller in volume due to the reduced number of rounds carried.

M-50 type ammunition (ball, HEI or API) for each gun is contained in an ammunition box in each gun compartment. Linked ammunition is fed through a standard flexible feedchute from the box to the guns. Ammunition links are retained in the aircraft after firing, in a compartment located beneath the aft end of the gun. Expended shell cases are ejected overboard.

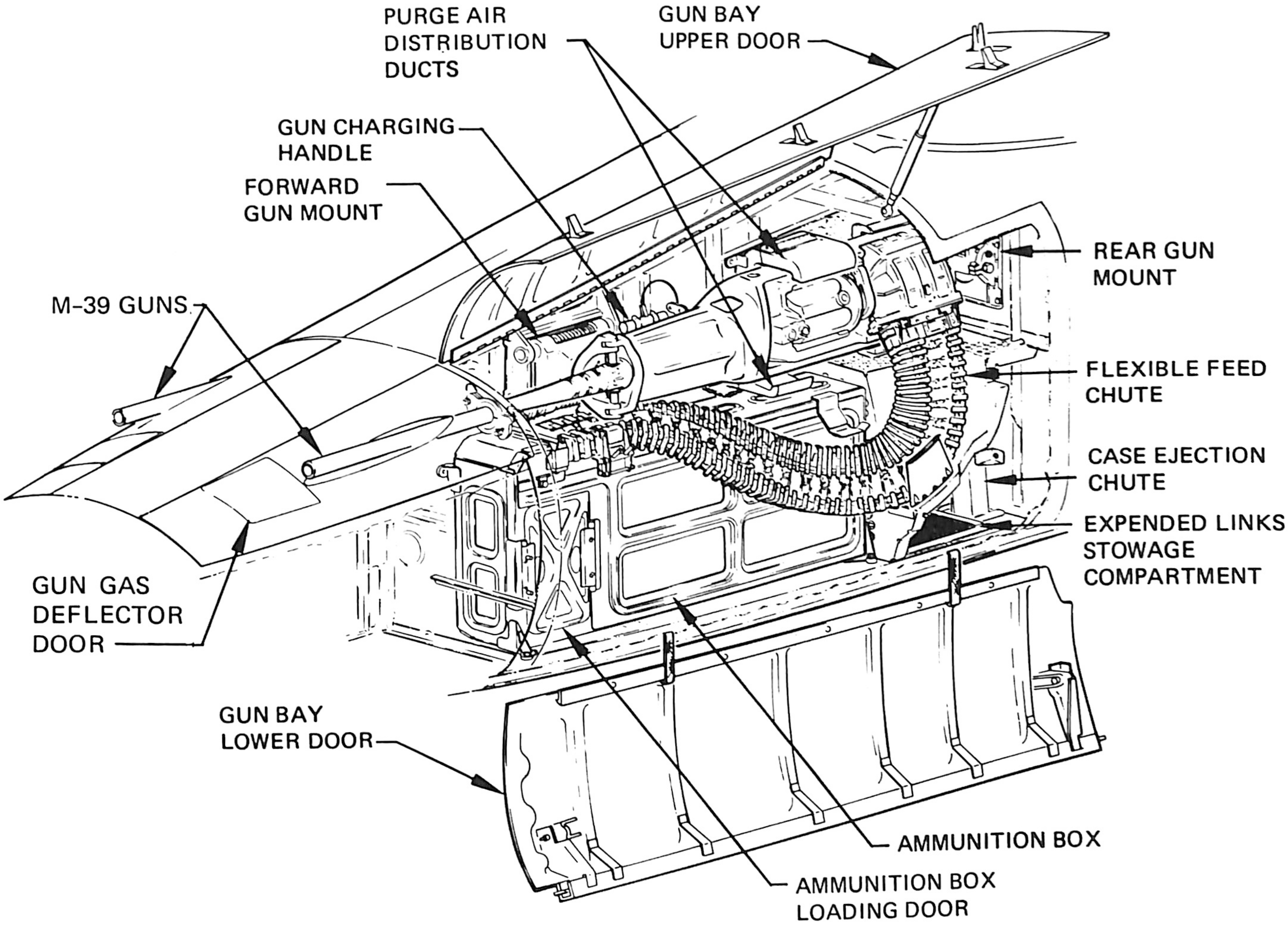

PURGE AIR DISTRIBUTION DUCTS
GUN BAY UPPER DOOR
GUN CHARGING HANDLE
FORWARD GUN MOUNT
M-39 GUNS
REAR GUN MOUNT
FLEXIBLE FEED CHUTE
CASE EJECTION CHUTE
EXPENDED LINKS STOWAGE COMPARTMENT
GUN GAS DEFLECTOR DOOR
GUN BAY LOWER DOOR
AMMUNITION BOX
AMMUNITION BOX LOADING DOOR

FIGURE 4-85. F-5E M-39 GUN INSTALLATION

The gun compartment can be serviced without the use of maintenance stands or special AGE. All components of the gun installation are readily removable from the aircraft to enable bench checkout or component replacement. Access to the gun and ammunition containers is facilitated through two large nonstructural doors on each side of the aircraft. The barrel, the revolver cylinder, and the feeder can be removed separately from the gun body without removing the gun body from the airplane, thus facilitating inspection and minor maintenance.

### AIM-9 Missile

The F-5E/F is equipped to launch two AIM-9 B, E or J Sidewinder IR seeking missiles. The AIM-9 missile has the capability to track and home on high-g maneuvering targets. The AIM-9 E or J missile guidance heads can be uncaged while still on the launcher, which permits the pilot to lead the target and maintain missile lock-on. The uncaging feature is provided by circuitry in the launcher power supply which is mounted in the wingtip launcher. Procedures for launching missiles are discussed in the subsequent Armament and Controls Subsection and the preceding Fire Control System subsection.

### External Stores

Seven store stations are provided externally on the F-5E/F aircraft. Each store station (except for wing tips) has a forced-ejection type of bomb rack mounted on the pylon. The location, store capacity and qualified stores carriage capability of each station are shown in Figure 4-86, together with additional growth stores that can be carried but which are not presently scheduled for qualification. Stores can be released or jettisoned selectively or salvoed as described under Armament Controls in this section.

Pylons. The F-5E/F provides for five externally mounted pylons.* These pylons include one centerline, two inboard, and two outboard wing pylons. Complete provisions for jettisoning the pylons are incorporated in the design. A description of optionally available jettison kits for all pylons is presented in Appendix A.

The centerline pylon assembly presented in Figure 4-87 is a cast aluminum beam structure which is approximately 98 inches long and extends 12 inches below the fuselage. It is attached to the fuselage by three bolts, one at Fuselage Station 295.25 and two at Fuselage Station 336.37. The pylon contains an MAU-40/A bomb rack with standard 30-inch and 14-inch lug spacing on which all centerline external stores are attached. Access is provided for electrical connections, fuel and air line connections, installation of bomb rack cartridges and jettison initiator and selection of ejection force settings. A three-position rotary ordnance selector switch on the left side of the pylon is provided for selecting the electrical circuitry required for the particular weapon load.

The inboard and outboard wing pylons shown in Figure 4-88 are aluminum castings. These pylons are mounted at wing stations 93.5 and 123.0 and may be installed on either side of the airplane. The inboard pylon is attached to the wing by five studs and the outboard pylon by four studs. Each pylon contains an MAU-50/A bomb rack with standard 14-inch lug spacing to enable attachment of external stores. Ordnance selector switches are provided on each pylon. Access is provided for electrical

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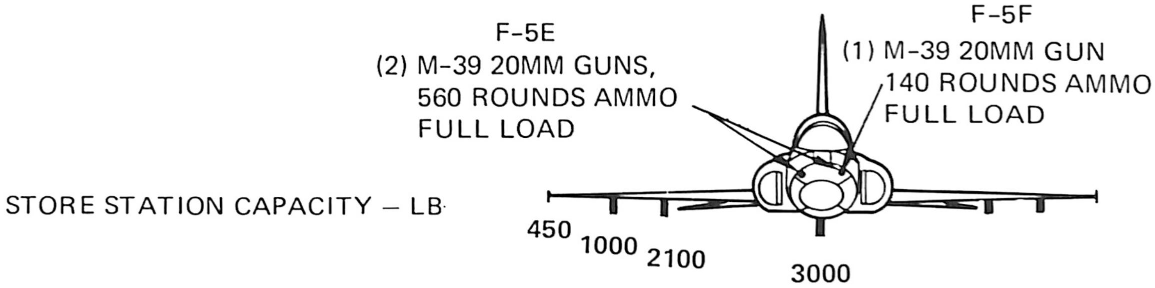
*F-5A/B pylons do not fit the F-5E/F.



| QUALIFIED STORES | TIP | OUTBD | INDB | ℄ | INBD | OUTBD | TIP |
|---|---|---|---|---|---|---|---|
| 150-GAL TANK | | | ● | ● | ● | | |
| 275-GAL TANK | | | ● | ● | ● | | |
| AIM-9B, AIM-9E, AIM-9J SIDEWINDER MISSILE | ● | | | | | | ● |
| TDU-11/B TARGET ROCKET | | | | | | | ● |
| AGM-65A MAVERICK MISSILE** | | ● | ● | | ● | ● | |
| M129E2 LEAFLET BOMB | | ● | ● | ● | ● | ● | |
| MK–36D DESTRUCTOR (MK–82SE & MOD KIT) | | ● | ● | ● | ● | ● | |
| MK-82 LD & SNAKEYE 500-LB BOMB | | ● | ● | ● | ● | ● | |
| MK-82 LGB-HS LASER GUIDED BOMB | | ● | ● | | ● | ● | |
| MK-84 LD 2000-LB BOMB | | | | ● | | | |
| BLU-1/B, BLU-1B/B, BLU-1C/B, 27/B, 27A/B, 27B/B, 27C/B FINNED AND UNFINNED FIRE BOMB | | ● | ● | ● | ● | ● | |
| BLU-32A/B, BLU-32B/B, BLU-32C/B FINNED AND UNFINNED FIRE BOMB | | ● | ● | ● | ● | ● | |
| CBU-24B/B, CBU-49B/B, CBU-52B/B, CBU-58/B, CBU-71/B CLUSTER BOMB | | ● | ● | ● | ● | ● | |
| LAU-68A/A (7) 2.75-INCH ROCKETS W/MK-1, MK-5, M151, M156 OR WDU-4 WARHEADS | | ● | ● | | ● | ● | |
| LAU-3/A, LAU-3A/A, LAU-3B/A, LAU-60/A (19) 2.75-INCH ROCKETS W/MK-1, MK-5, M151, M156 OR WDU-4 WARHEADS | | ● | ● | | ● | ● | |
| SUU-20/A(M), SUU-20A/A, SUU-20B/A BOMB AND ROCKET PACK | | | | ● | | | |
| SUU-25A/A, SUU-25C/A FLARE DISPENSER | | ● | | | | ● | |
| TDU-10/B TOW TARGET (DART W/CARRIER) | | | | | | ● | |
| RMU-10/A REEL (DART) | | | | ● | | | |
| MER-5E (5) MK-82 LD & SNAKEYE BOMBS | | | | ●●●●● | | | |

| GROWTH STORES (REQUIRE QUALIFICATION) | TIP | OUTBD | INDB | ℄ | INBD | OUTBD | TIP |
|---|---|---|---|---|---|---|---|
| 50-GAL TIP TANK | ● | | | | | | ● |
| M117, 750-LB BOMB | | ● | ● | ● | ● | ● | |
| ROCKEYE II (MK-20 MOD 2) CLUSTER BOMB | | ● | ● | ● | ● | ● | |
| MK-81 LD & SNAKEYE 250-LB BOMB | | ● | ● | ● | ● | ● | |
| MK-82 LGB-HS LASER GUIDED BOMB | | | | ● | | | |
| MK-82 LGB-LS LASER GUIDED BOMB (2) OUTBOARD OR (2) INBOARD ONLY | | ● | ● | | ● | ● | |
| MK-83 LD 1000-LB BOMB | | ● | ● | ● | ● | ● | |
| CBU-2A/A, CBU-9/A CLUSTER BOMB | | ● | | | | ● | |
| LAU-10/A (4) 5-INCH ROCKETS W/MK-24 MOD 0, MK-32 MOD 0, MK-6 MODS 1 AND 4 OR MK-25 WARHEADS | | ● | | | | ● | |
| TER* W/MK-81 LD AND SNAKEYE BOMBS | | ●● | ●●● | ●●● | ●●● | ●● | |
| MER-5E (5) MK-81 LD AND SNAKEYE BOMBS | | | | ●●●●● | | | |
| TER* MK-82 LD AND SNAKEYE BOMBS | | | ●● | ●●● | ●● | | |
| TER* (2) ROCKEYE II CLUSTER BOMBS | | | | ●● | | | |

*RACK REQUIRES DESIGN AND DEVELOPMENT

**REFER TO APPENDIX A FOR DESCRIPTION OF MAVERICK LAUNCH AND CONTROL SYSTEM INSTALLATION.

FIGURE 4-86. F-5E/F EXTERNAL STORES CAPABILITY

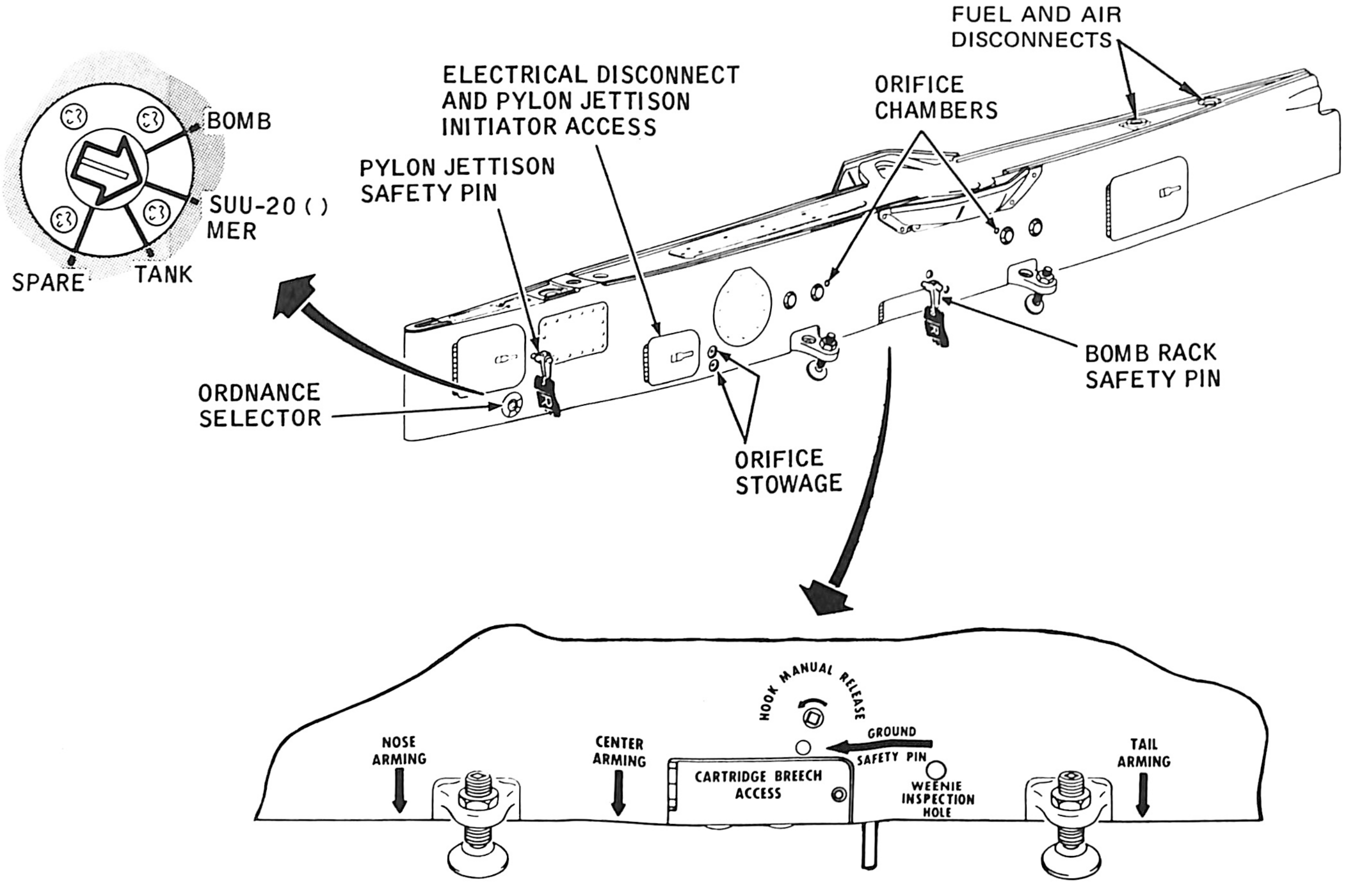

BOMB
SUU-20 ( )
MER
SPARE
TANK
ELECTRICAL DISCONNECT AND PYLON JETTISON INITIATOR ACCESS
PYLON JETTISON SAFETY PIN
FUEL AND AIR DISCONNECTS
ORIFICE CHAMBERS
ORDNANCE SELECTOR
ORIFICE STOWAGE
BOMB RACK SAFETY PIN
HOOK MANUAL RELEASE
NOSE ARMING
CENTER ARMING
CARTRIDGE BREECH ACCESS
GROUND SAFETY PIN
WEENIE INSPECTION HOLE
TAIL ARMING

FIGURE 4-87. F-5E/F CENTERLINE PYLON

connections, installation of bomb rack cartridges, and the selection of ejection force settings. The inboard pylon also has accommodations for access to the fuel and air line connections.

Bomb Racks. The bomb rack is a separate unit installed as a complete assembly in the pylon. MAU-50/A bomb racks are installed in the four underwing pylons. These racks have 14-inch-spaced suspension hooks that adapt to standard 14-inch external store suspension lugs. An MAU-40/A rack with two sets of suspension hooks, 14-inch and 30-inch, that adapt to standard 14-inch and 30-inch external store suspension lugs, is installed in the centerline pylon. Power required to eject the store from the rack hooks is obtained from the combined explosive charges of the two electrically fired ejector cartridges, which are installed in the rack. These cartridges are ignited by the aircraft dual armament circuitry but both will fire from sympathetic ignition even if one circuit fails.

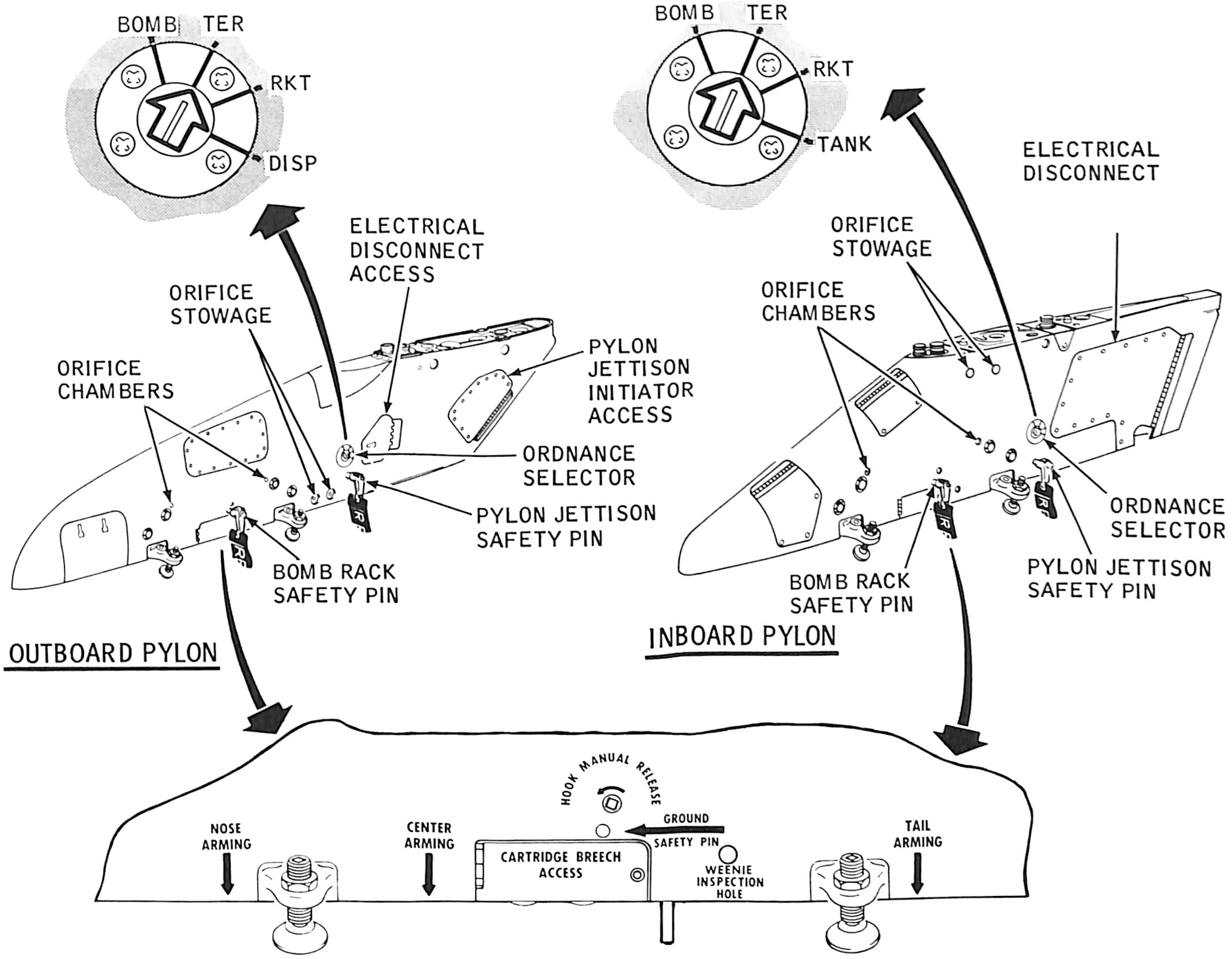

BOMB
TER
RKT
DISP
ELECTRICAL DISCONNECT ACCESS
ORIFICE STOWAGE
ORIFICE CHAMBERS
PYLON JETTISON INITIATOR ACCESS
ORDNANCE SELECTOR
PYLON JETTISON SAFETY PIN
BOMB RACK SAFETY PIN
OUTBOARD PYLON
BOMB
TER
RKT
TANK
ELECTRICAL DISCONNECT
ORIFICE STOWAGE
ORIFICE CHAMBERS
ORDNANCE SELECTOR
PYLON JETTISON SAFETY PIN
BOMB RACK SAFETY PIN
INBOARD PYLON
HOOK MANUAL RELEASE
NOSE ARMING
CENTER ARMING
CARTRIDGE BREECH ACCESS
GROUND SAFETY PIN
WEENIE INSPECTION HOLE
TAIL ARMING

FIGURE 4-88. F-5E/F INBOARD AND OUTBOARD WING PYLONS

A dual purpose ground safety pin, when fully inserted in the left side of the pylon, mechanically locks the bomb rack suspension hooks and opens the electrical circuit to the ejector cartridge breeches. With the safety pin positioned at the first detent (not fully inserted), the electrical circuit to the cartridge breeches is closed, but in the event the cartridges are accidentally fired the suspension hooks will remain mechanically locked retaining the installed store.

Three arming solenoids at the front, center and rear of the bomb rack provide for nose, nose and tail, or tail-only arming of bomb fuses. The solenoids are energized by selection on the BOMBS ARM switch in the cockpit. A store presence sensing switch is located on the underside of the bomb rack between the release hooks.

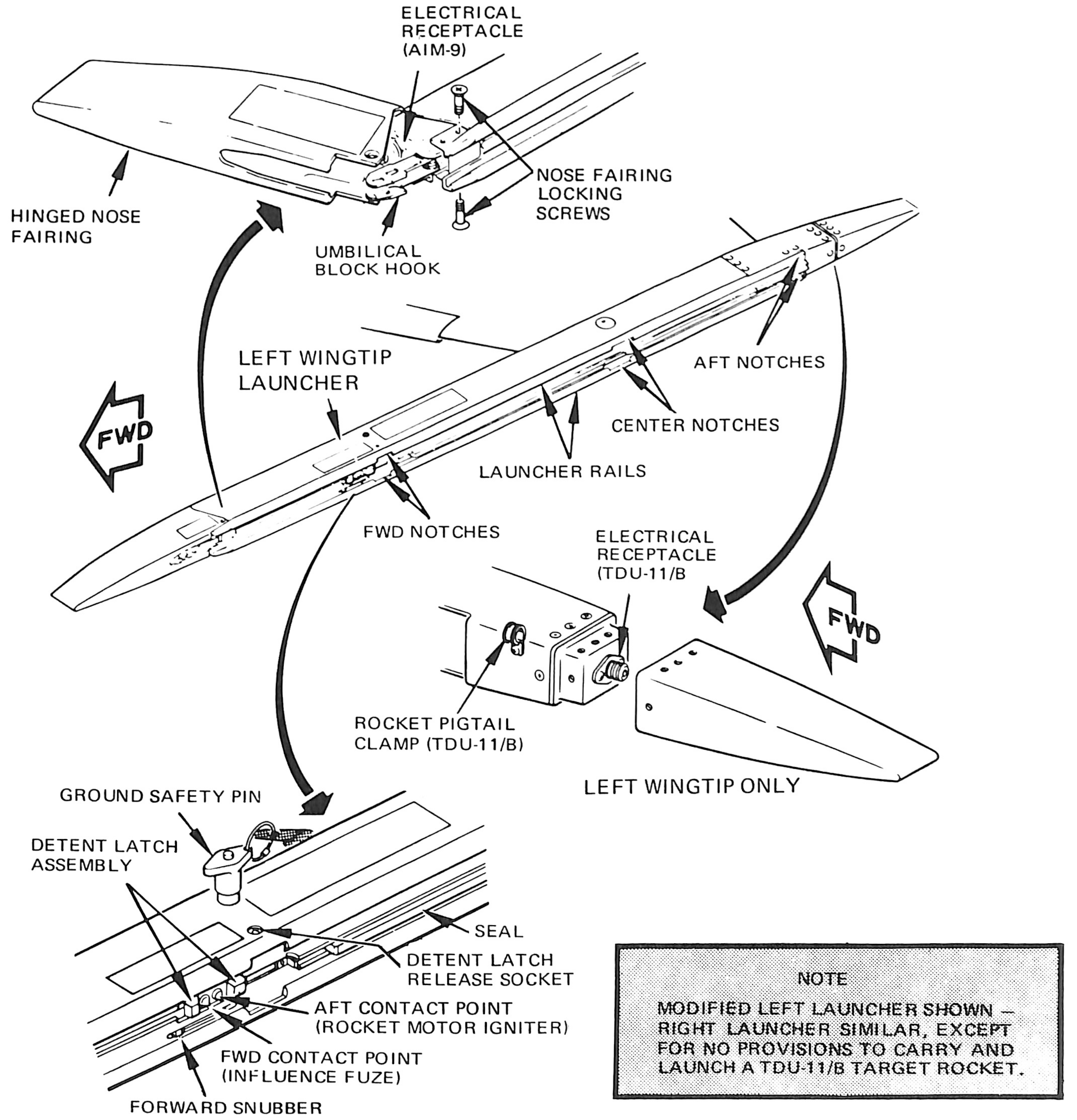
The multiple ejector rack (MER-5E) is optional equipment that can be installed on the F-5E/F aircraft. A detailed description of the MER-5E is presented in Appendix A.

The triple ejector rack (TER) will be optional equipment for the F-5E/F but it requires development and qualification. The TER will accommodate up to three bombs, function the same as the MER, and will be designed to be carried on all pylon stations.

Wingtip. The wingtip will carry AIM-9 B, E or J missiles and the TDU-11B Target Rocket (LH side only). The wingtip also contains complete provisions for 50-gallon fuel tanks as discussed in the external fuel system description. Detachable wingtip launchers, one on each wingtip, are provided for carrying and firing the missiles. The launcher, shown in Figure 4-89, although detachable from the wingtip, becomes an integral part of the wing when it is installed.

The launcher contains the missile power supply necessary to control the guidance and launching units of the missile. The power supply furnishes filament voltages and power to an electrical caging circuit to cage and uncage the missile gyro; it also supplies power for the squib safety circuit, power-interlock circuit, jettison circuit, firing circuit to the gas generator, and firing circuit to the rocket motor, as well as the required heating voltages. The power supply also contains an audio amplifier which amplifies the missile audio tone to inform the pilot when the missile seeker is pointed at the target.

The launcher is equipped with a detent latch to retain the missile on the launcher, and snubbers which wedge the forward and aft missile hangers firmly in place to prevent missile sway during flight. A forward thrust of 1500 to 1800 pounds is required


ELECTRICAL RECEPTACLE (AIM-9)
HINGED NOSE FAIRING
NOSE FAIRING LOCKING SCREWS
UMBILICAL BLOCK HOOK
LEFT WINGTIP LAUNCHER
FWD
AFT NOTCHES
CENTER NOTCHES
LAUNCHER RAILS
FWD NOTCHES
ELECTRICAL RECEPTACLE (TDU-11/B
FWD
ROCKET PIGTAIL CLAMP (TDU-11/B)
LEFT WINGTIP ONLY
GROUND SAFETY PIN
DETENT LATCH ASSEMBLY
SEAL
DETENT LATCH RELEASE SOCKET
AFT CONTACT POINT (ROCKET MOTOR IGNITER)
FWD CONTACT POINT (INFLUENCE FUZE)
FORWARD SNUBBER

NOTE

MODIFIED LEFT LAUNCHER SHOWN – RIGHT LAUNCHER SIMILAR, EXCEPT FOR NO PROVISIONS TO CARRY AND LAUNCH A TDU-11/B TARGET ROCKET.

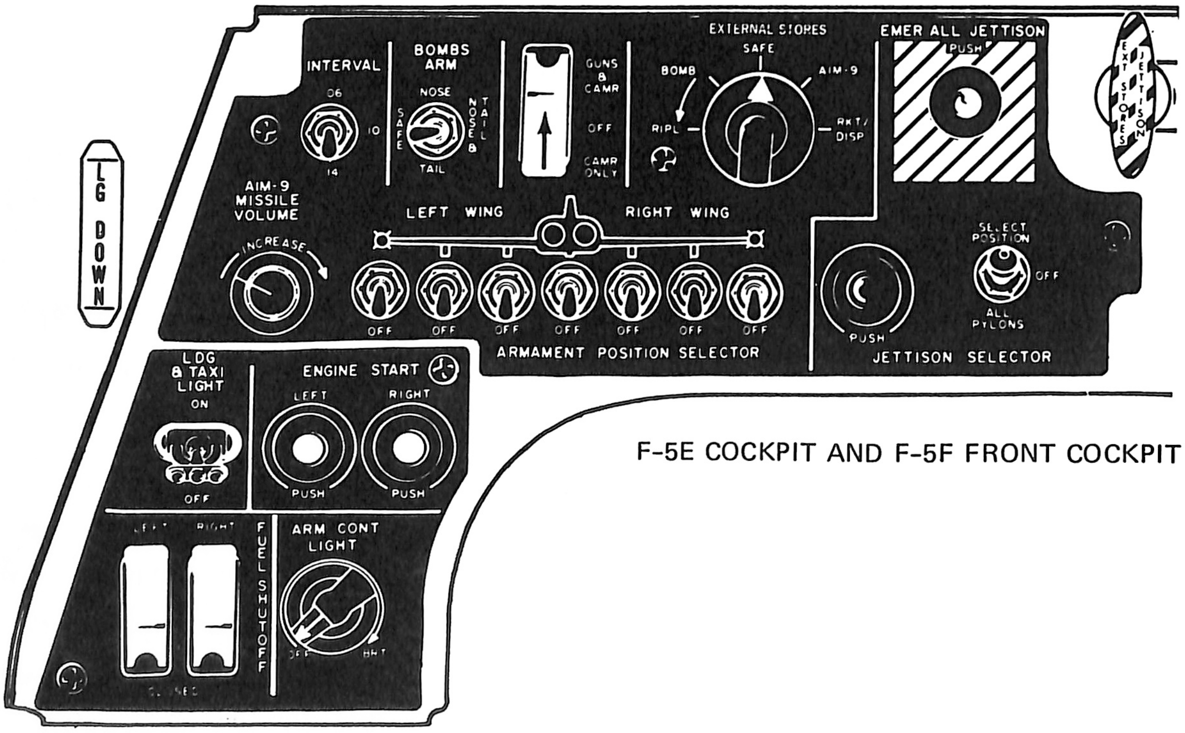
FIGURE 4-89. F-5E/F WINGTIP LAUNCHERS

to overcome the spring force of the detent latch. An umbilical receptacle on the forward end of the launcher and two contact points in the detent latch provide the electrical connection to the missile. A safety switch, inboard of the detent latch release socket, interrupts the missile motor firing circuit whenever the launcher safety pin is installed. The launcher electrical circuits are energized by the aircraft armament circuitry.

A TDU-11/B 5.0-inch HVAR target rocket can be carried and fired in place of a missile on the left wingtip launcher. A jack-plug receptacle on the rear provides for the electrical connection to the target rocket. The target is retained on the left wingtip launcher in the same manner as the AIM-9 missile.

## Armament Controls

The armament control panel shown in Figure 4-90 is located on the left-hand vertical console (front cockpit only in the F-5F) to provide selective release of weapons carried by the aircraft. The EXTERNAL STORES switch is used to select the type of weapon to be released and, in the case of bombs, ripple release. The ARMAMENT POSITION SELECTOR switches are used to select the particular weapon station. A BOMBS ARM switch is provided to select either safe, nose-only, nose-and-tail or tail-only bomb arming. An INTERVAL control provides ripple interval control when bomb RIPL is selected on the armament mode selector switch. The three settings are 0.06, 0.10 and 0.14 seconds. The intervalometer will ripple release munitions and is used with pylon bomb racks, the MER -5E and TER's.


LG DOWN
INTERVAL
06
10
14
BOMBS ARM
NOSE
SAFE
NOSE & TAIL
TAIL
GUNS & CAMR
OFF
CAMR ONLY
EXTERNAL STORES
SAFE
BOMB
AIM-9
RIPL
RKT/DISP
EMER ALL JETTISON
PUSH
EXT STORES JETTISON
AIM-9 MISSILE VOLUME
INCREASE
LEFT WING
RIGHT WING
OFF
OFF
OFF
OFF
OFF
OFF
OFF
ARMAMENT POSITION SELECTOR
SELECT POSITION
OFF
ALL PYLONS
PUSH
JETTISON SELECTOR
LDG & TAXI LIGHT
ON
OFF
ENGINE START
LEFT
RIGHT
PUSH
PUSH
LEFT
RIGHT
FUEL SHUTOFF
CLOSED
ARM CONT LIGHT
OFF
BRT

F-5E COCKPIT AND F-5F FRONT COCKPIT

FIGURE 4-90. F-5E/F ARMAMENT CONTROL PANEL

The MER-5E has, in addition, an integral ripple release selector which is set to BOMBS (low drag bombs) or SNAKEYE RIPPLE (high drag bombs) in accordance with the type of bombs loaded.

The external stores are released or fired by depressing the missile/bomb/rocket button on the control stick (both cockpits in the F-5F) which simultaneously turns on the gun camera regardless of GUNS & CAMR switch position. The camera overrun feature is activated on release of the missile/bomb/rocket button. If bombs on all stations are selected for salvo release with the EXTERNAL STORES switch in the BOMB position, the outboard and centerline stores will be released immediately followed 0.15 second later by both inboard stores.

Selective jettison capability is provided for outboard, inboard, centerline, and wingtip stores. To selectively jettison pylon and wingtip stores, the pilot selects the desired store station on the ARMAMENT POSITION SELECTOR. Selection can be made of a single wing station or wing tip, a pair of opposite wing stations, both wing tips, or the centerline station. The pilot then places the jettison selector switch in the SELECT POSITION and pushes the jettison pushbutton (front cockpit only in the F-5F) which jettisons the selected store(s).

Two methods of stores emergency salvo jettison are also provided: electrically, by pushing the EMER ALL JETTISON button (both cockpits in the F-5F), with power from the dc bus; or electromechanically, by pulling the EXT STORES JETTISON T-handle (front cockpit only in the F-5F) utilizing power from a one-time emergency thermal battery source (the T-handle, once pulled, cannot be returned to the stored position until the thermal battery is replaced and the thermal battery switch is reset on the ground). When stores are salvo jettisoned by any method, the stores are released in the following order: (1) outboard stores immediately, (2) centerline store 0.2 second later, and (3) inboard stores 0.3 second after centerline store except when carrying full or partially filled fuel tanks in which case the tanks will be released 0.8 second after the centerline store. In all jettison procedures, the stores are dropped in the safe or unarmed condition.

Capability is provided for salvo jettison of all pylons. To jettison the pylons, when optional pylon jettison kits are installed, the pilot sets the jettison selector switch (front cockpit only in the F-5F) to the ALL PYLONS position. The jettison pushbutton is then depressed and the automatic sequence for jettison of pylon stores is initiated after which all pylons are simultaneously jettisoned.

The capability to selectively launch AIM-9 missiles is provided on the ARMAMENT POSITION SELECTOR; left, right or both wingtip positions may be selected. Placing the EXTERNAL STORES switch in the AIM-9 position arms the missile circuitry and activates the missile guidance and control system. Acquisition of a target by the missile will cause a tone to be generated in the missile which is fed to the pilot's headset (with both missiles selected, only the left missile generates a tone to the pilot's headset). The pilot can adjust the volume of the tone with the AIM-9 VOLUME control on the armament control panel. Volume control is available in the front cockpit only in the F-5F. However, the tone is duplicated in the rear cockpit headset. When the pilot hears the tone and he is carrying AIM-9 E or J missiles, he can elect to uncage the missile seeker head (front cockpit only in the F-5F) if he determines target lead angle is required. The missile is uncaged by actuating the missile uncage switch located on the left-hand power control lever (F-5F front cockpit only). The missile seeker head will return to the caged position upon release of the switch. Whether caged or uncaged, the missile tone indicates that missile guidance lock-on has been accomplished, and the missile can be launched by pressing the missile/bomb/rocket button on the control stick grip (front cockpit only in F-5F). If both missiles have been selected, the left missile will fire first. When the left missile leaves the launcher, the audio tone channel transfers to the right missile automatically. If a second missile is needed, actuating the missile/bomb/rocket button a second time fires the right-hand missile.

Gun controls consist of a three-position GUNS & CAMR switch on the armament control panel (front cockpit only in the F-5F) and a conventional trigger switch on the control stick. The trigger in the F-5F rear cockpit is inoperative. The GUNS & CAMR switch on the panel has a central OFF position and can be positioned to energize both the camera and guns simultaneously, or the camera only. The first detent position of the trigger switch actuates the camera, gun bay purge system, and gun-gas deflectors; the second detent position of the trigger switch fires the guns.

Safety features of the armament control system include a guard clip over the GUNS & CAMR switch that must be raised before the switch can be thrown to arm the circuits. All external weapons are protected against accidental release by the detented external stores switch on the control panel. This switch must be depressed and turned to select a weapon mode. In addition to the cockpit safety devices, an armament safety switch on the left main gear prevents firing or release of any weapon until the weight of the aircraft is off the ground; however, stores may be jettisoned when the aircraft is still on the ground.

## Weapons Training

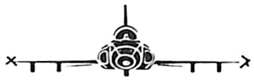
F-5E/F aircraft are designed to carry the SUU-20 type practice bomb and rocket dispenser which can accommodate six BDU-33 type or high-drag MK-106 practice bombs and four 2.75 FFAR rockets. The F-5E/F can also fire the TDU-11/B target rocket from the left wingtip launcher for use as an air-to-air missile target. M-55 ball (practice) ammunition is available for use in the 20mm guns. For air-to-air gunnery, the A/A 37U-15 Tow Target system can be carried on either the F-5E or F-5F. The system deploys the TDU-10/B Dart Tow Target from the left outboard pylon.

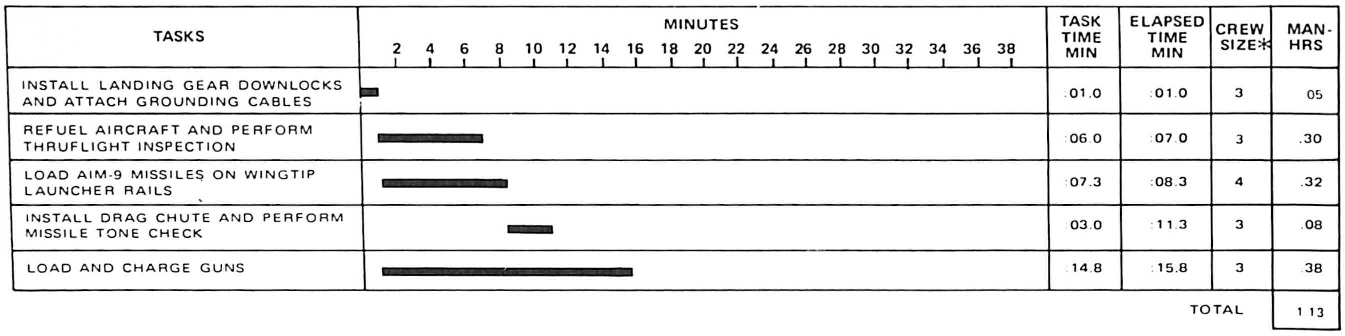
## Turnaround Capability

An aircraft turnaround consists of servicing, rearming, and thru-flight inspecting between consecutive missions with the elapsed time being measured from engine shutdown to aircraft ready for engine start. Figures 4-91 and 4-92 summarize the F-5E and F-5F detailed turnaround elapsed times and man-hours required for three representative missions. These figures indicate the crew size and time phasing for each activity during the turnaround. Included in the turnaround data is the period of time required to service and reload the guns, to load bombs and missiles, and to refuel and inspect the aircraft. These elapsed time estimates have been determined from available USAF operational data utilizing USAF training standards and procedures. Weapons maintenance and loading crews are allocated in accordance with AFM 26-3, Codes 2511C, 2512C, and 2513C. Authorizations are for one (1) four-man loading crew for each two (2) F-5 aircraft, one (1) Weapons Release Technician for each three (3) F-5 aircraft and a three (3) man crew to service the F-5E guns (2 men for F-5F) with one (1) gun technician for each seven (7) F-5E aircraft or each nine (9) F-5F aircraft. Table of allowances authorizes three (3) MJ-1 Bomb Lift Trucks per 18 F-5 aircraft. In view of these authorizations, only one weapons loading/release crew and one gun services crew were utilized in determining the turnaround analysis.

The related functions of arming prior to takeoff and dearming after landing have not been included in the turnaround analysis due to intervening taxi times, remoteness to the arming and dearming area, and varying operational policies concerned with these events.

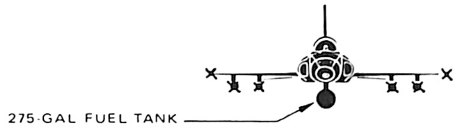
COUNTER AIR MISSION

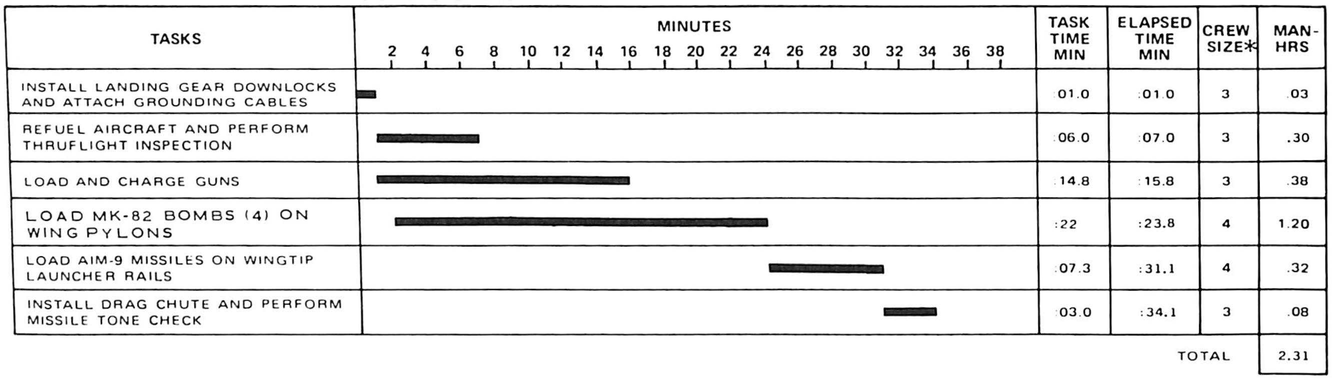




| TASKS | TASK TIME MIN | ELAPSED TIME MIN | CREW SIZE* | MAN-HRS |
|---|---|---|---|---|
| INSTALL LANDING GEAR DOWNLOCKS AND ATTACH GROUNDING CABLES | :01.0 | :01.0 | 3 | 05 |
| REFUEL AIRCRAFT AND PERFORM THRUFLIGHT INSPECTION | :06.0 | :07.0 | 3 | .30 |
| LOAD AIM-9 MISSILES ON WINGTIP LAUNCHER RAILS | :07.3 | :08.3 | 4 | .32 |
| INSTALL DRAG CHUTE AND PERFORM MISSILE TONE CHECK | :03.0 | :11.3 | 3 | .08 |
| LOAD AND CHARGE GUNS | :14.8 | :15.8 | 3 | .38 |
|  |  |  | TOTAL | 1.13 |

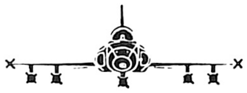
CLOSE AIR SUPPORT

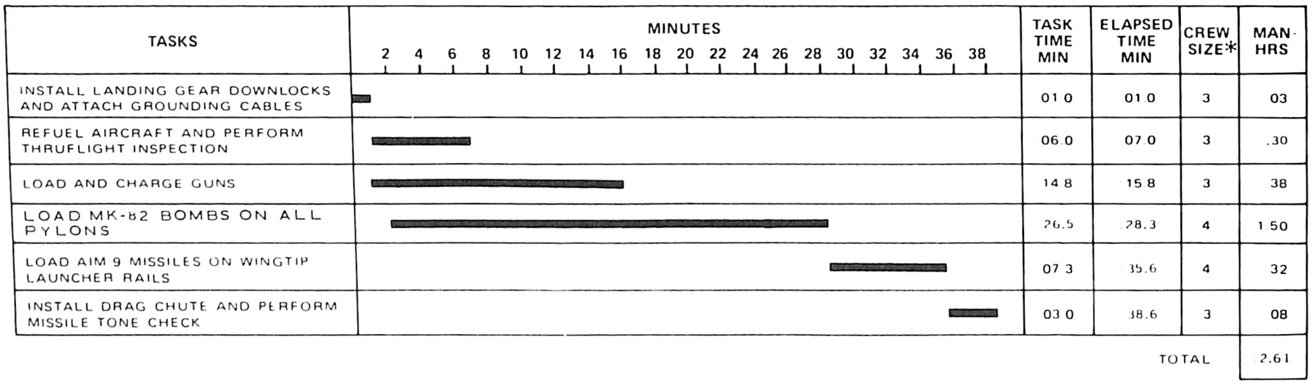




| TASKS | TASK TIME MIN | ELAPSED TIME MIN | CREW SIZE* | MAN-HRS |
|---|---|---|---|---|
| INSTALL LANDING GEAR DOWNLOCKS AND ATTACH GROUNDING CABLES | 01.0 | :01.0 | 3 | .03 |
| REFUEL AIRCRAFT AND PERFORM THRUFLIGHT INSPECTION | :06.0 | :07.0 | 3 | .30 |
| LOAD AND CHARGE GUNS | :14.8 | :15.8 | 3 | .38 |
| LOAD MK-82 BOMBS (4) ON WING PYLONS | :22 | :23.8 | 4 | 1.20 |
| LOAD AIM-9 MISSILES ON WINGTIP LAUNCHER RAILS | :07.3 | :31.1 | 4 | .32 |
| INSTALL DRAG CHUTE AND PERFORM MISSILE TONE CHECK | :03.0 | :34.1 | 3 | .08 |
|  |  |  | TOTAL | 2.31 |

IN-COUNTRY INTERDICTION





| TASKS | TASK TIME MIN | ELAPSED TIME MIN | CREW SIZE* | MAN-HRS |
|---|---|---|---|---|
| INSTALL LANDING GEAR DOWNLOCKS AND ATTACH GROUNDING CABLES | 01.0 | 01.0 | 3 | 03 |
| REFUEL AIRCRAFT AND PERFORM THRUFLIGHT INSPECTION | 06.0 | 07.0 | 3 | .30 |
| LOAD AND CHARGE GUNS | 14.8 | 15.8 | 3 | 38 |
| LOAD MK-82 BOMBS ON ALL PYLONS | 26.5 | :28.3 | 4 | 1.50 |
| LOAD AIM 9 MISSILES ON WINGTIP LAUNCHER RAILS | 07.3 | 35.6 | 4 | 32 |
| INSTALL DRAG CHUTE AND PERFORM MISSILE TONE CHECK | 03.0 | 38.6 | 3 | 08 |
|  |  |  | TOTAL | 2.61 |

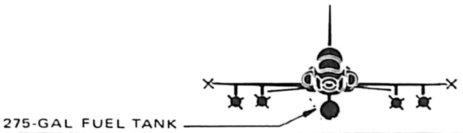
* MAXIMUM CREW SIZE UTILIZED AT ANY ONE TIME TO ACCOMPLISH TASK

FIGURE 4-91. F-5E TURNAROUND ANALYSIS – FULL AMMUNITION

## COUNTER AIR MISSION

| TASKS | MINUTES<br>2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 | TASK TIME MIN | ELAPSED TIME MIN | CREW SIZE* | MAN-HRS |
|---|---|---|---|---|---|
| INSTALL LANDING GEAR DOWNLOCKS AND ATTACH GROUNDING CABLES | ▬ | :01.0 | :01.0 | 3 | .05 |
| REFUEL AIRCRAFT AND PERFORM THRUFLIGHT INSPECTION | ▬ | :06.0 | :07.0 | 3 | .30 |
| LOAD AIM-9 MISSILES ON WINGTIP LAUNCHER RAILS | ▬ | :07.3 | :08.3 | 4 | .32 |
| INSTALL DRAG CHUTE AND PERFORM MISSILE TONE CHECK | ▬ | :03.0 | :11.3 | 3 | .08 |
| LOAD AND CHARGE GUNS | ▬ | 7.4 | 11.3 | 2 | .19 |
| | | | | TOTAL | .94 |

## CLOSE AIR SUPPORT



| TASKS | MINUTES<br>2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 | TASK TIME MIN | ELAPSED TIME MIN | CREW SIZE* | MAN-HRS |
|---|---|---|---|---|---|
| INSTALL LANDING GEAR DOWNLOCKS AND ATTACH GROUNDING CABLES | ▬ | :01.0 | :01.0 | 3 | .05 |
| REFUEL AIRCRAFT AND PERFORM THRUFLIGHT INSPECTION | ▬ | :06.0 | :07.0 | 3 | .30 |
| LOAD AND CHARGE GUNS | ▬ | 7.4 | 8.1 | 2 | .19 |
| LOAD MK-82 BOMBS (4) ON WING PYLONS | ▬ | :22 | :23.8 | 4 | 1.20 |
| LOAD AIM-9 MISSILES ON WINGTIP LAUNCHER RAILS | ▬ | :07.3 | :31.1 | 4 | .32 |
| INSTALL DRAG CHUTE AND PERFORM MISSILE TONE CHECK | ▬ | :03.0 | :34.1 | 3 | .08 |
| | | | | TOTAL | 2.14 |

## IN-COUNTRY INTERDICTION

| TASKS | MINUTES<br>2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 | TASK TIME MIN | ELAPSED TIME MIN | CREW SIZE* | MAN-HRS |
|---|---|---|---|---|---|
| INSTALL LANDING GEAR DOWNLOCKS AND ATTACH GROUNDING CABLES | ▬ | :01.0 | :01.0 | 3 | .05 |
| REFUEL AIRCRAFT AND PERFORM THRUFLIGHT INSPECTION | ▬ | :06.0 | :07.0 | 3 | .30 |
| LOAD AND CHARGE GUNS | ▬ | 7.4 | :08.4 | 2 | .19 |
| LOAD MK-82 BOMBS ON ALL PYLONS | ▬ | :26.5 | :28.3 | 4 | 1.50 |
| LOAD AIM-9 MISSILES ON WINGTIP LAUNCHER RAILS | ▬ | :07.3 | :35.6 | 4 | .32 |
| INSTALL DRAG CHUTE AND PERFORM MISSILE TONE CHECK | ▬ | :03.0 | :38.6 | 3 | .08 |
| | | | | TOTAL | 2.44 |

* MAXIMUM CREW SIZE UTILIZED AT ANY ONE TIME TO ACCOMPLISH TASK.

FIGURE 4-92. F-5F TURNAROUND ANALYSIS – FULL AMMUNITION

## SECTION 5

# MAINTENANCE AND SUPPORT INFORMATION

# SECTION 5

# MAINTENANCE AND SUPPORT INFORMATION

The maintenance and system support requirements of an aircraft are a direct reflection of its design characteristics. Design criteria for the F-5E/F were established to emphasize reliability, maintainability, operational flexibility, and multimission capability. The results are reflected in an aircraft that is simple to maintain, has rapid turnaround and recovery rates, and has the capability for high sustained sortie and operational readiness rates. To maximize utilization of these capabilities, user nation detailed planning should be based on the specific mission assignments and completed well in advance of receipt of the first F-5E/F aircraft. Mission requirements must be developed in detail to define the various armament and fuel configurations that will satisfy operational objectives. The user country can establish appropriate maintenance and support requirements only after the aircraft configuration, missions, operational concept, and environment are defined specifically.

To aid the user in developing an adequate maintenance and support system, a support planning guide has been prepared, NB74-55. The following brief discussion of AGE and training equipment were derived from this document.

Aerospace Ground Equipment (AGE) for the F-5E/F aircraft was designed as an integral part of the entire weapon system. The guiding principles were to (1) use standard tools and equipment wherever possible, (2) avoid use of complex multipurpose testers, (3) keep handling equipment simple and convenient, and (4) design for use by mechanics of minimum skill levels.

AGE (including test equipment, tools, and ground handling equipment) is characterized by simplicity of design, maintenance, operation, and ease of handling Light airframe weight of the F-5E/F eliminates the requirement for large, cumbersome AGE. The aft fuselage section (called the boat-tail), wings, and the J85-GE-21 engines all are easily removed with simple AGE. A typical group of major AGE units is shown in Figure 5-1.

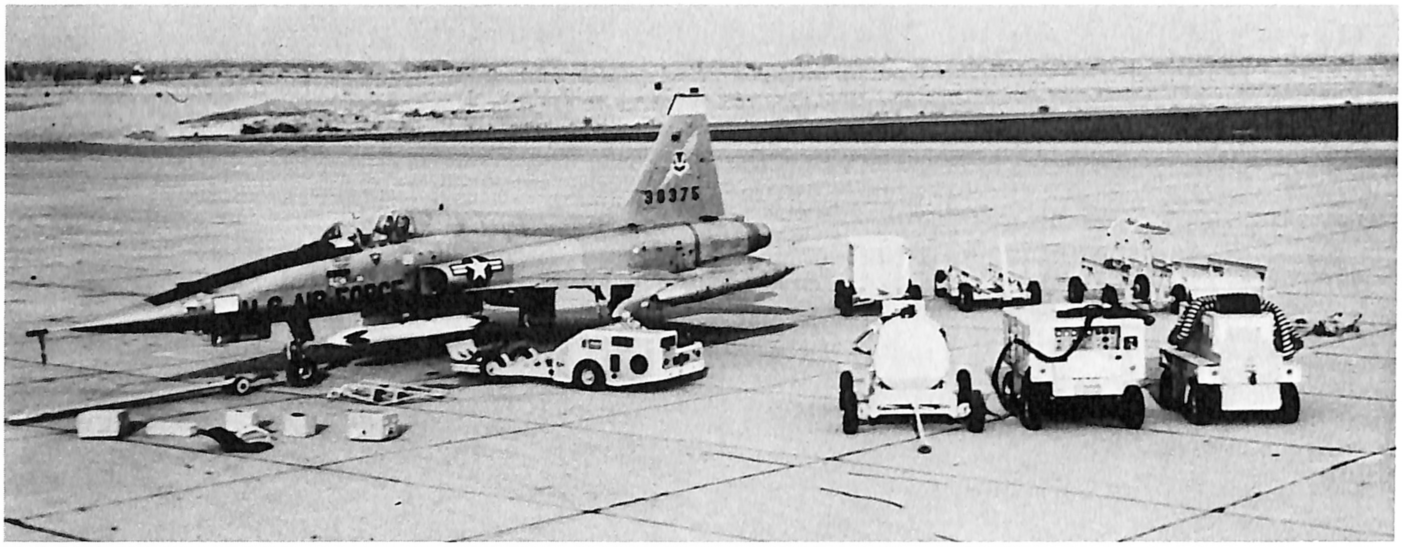


FIGURE 5-1. MAJOR AGE UNITS

## BASIC AGE ITEMS

The following descriptions identify major items considered to be the basic AGE necessary to accomplish F-5E/F maintenance. User nations will require the equipment as identified, or an equivalent item that is compatible with or adaptable to F-5E/F functional requirements.

### Ground Servicing

The basic ground servicing equipment used to prepare the F-5E/F aircraft for flight consists of the following:

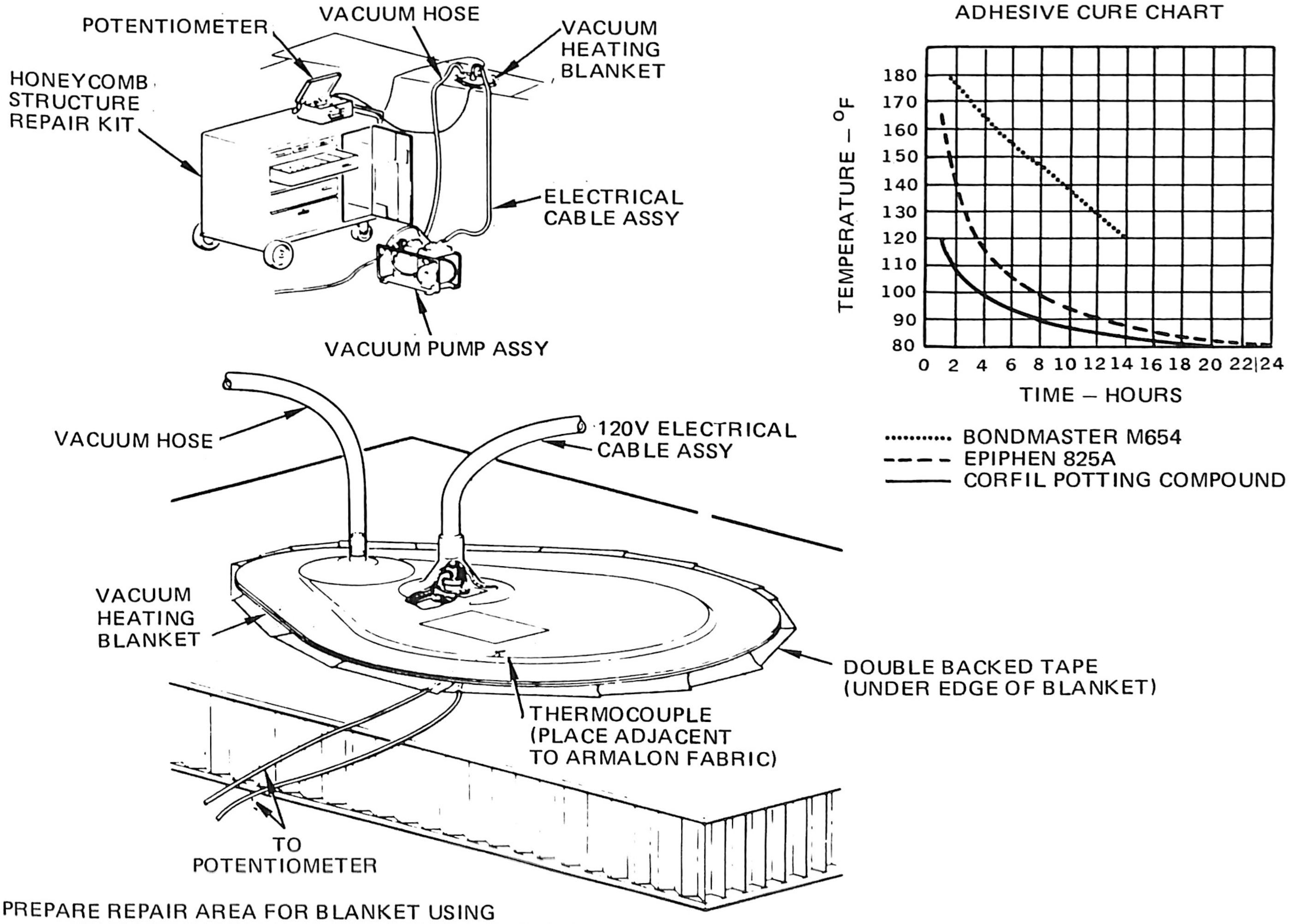
1. EM-J1 Fuel Trailer
2. MA-1 or TMU-27M, 50-Gallon LOX Trailer (F-5E only. Not required for F-5F)
3. AFM32A10 or B10A Electrical Power Unit (for power-on preflight check)
4. MA-1A Starting Unit or equivalent
5. EM-J24 Hydraulic Test Stand
6. MJ-1 Bomb Lift Truck.

## Component Handling

Handling of the engine and major structural components of the F-5E/F is accomplished through the use of a component-handling system. This lightweight equipment features a 30-inch, twin-rail system. The basic system is composed of a lift trailer, a transportation trailer, and a workstand with roll-over adapters for the engines, aft fuselage, and wing. A step-down adapter is available for use in converting standard twin-rail equipment to the smaller 30-inch size.

## Honeycomb Structure Repair Kit

The honeycomb structure repair kit, as shown in Figure 5-2, has been designed to ensure that all items of equipment and material included are compatible with the latest processes being used in the manufacture of the F-5E/F aircraft. The kit, now a standard USAF item, consists of approximately 100 tool and consumable material components.


POTENTIOMETER
VACUUM HOSE
VACUUM HEATING BLANKET
HONEYCOMB STRUCTURE REPAIR KIT
ELECTRICAL CABLE ASSY
VACUUM PUMP ASSY
ADHESIVE CURE CHART
TEMPERATURE – °F
180
170
160
150
140
130
120
110
100
90
80
0 2 4 6 8 10 12 14 16 18 20 22 24
TIME – HOURS
·········· BONDMASTER M654
– – – – EPIPHEN 825A
——— CORFIL POTTING COMPOUND
VACUUM HOSE
120V ELECTRICAL CABLE ASSY
VACUUM HEATING BLANKET
DOUBLE BACKED TAPE (UNDER EDGE OF BLANKET)
THERMOCOUPLE (PLACE ADJACENT TO ARMALON FABRIC)
TO POTENTIOMETER

PREPARE REPAIR AREA FOR BLANKET USING
ARMALON FABRIC (1.00 INCH BEYOND REPAIR)
ALUMINUM PRESSURE PLATE (0.064 INCH AND SAME SIZE AS FABRIC)
VENT CLOTH (4.00 INCHES BEYOND PLATE)

FIGURE 5-2. HONEYCOMB STRUCTURE REPAIR KIT

## Engine Test

Engine runup and test for the J85-21 engines is performed by using either a standard A/M37T-6C, Space Corporation 20,000-pound-thrust test stand or the portable engine maintenance system described on the following page. Adapters are provided for incorporation on these stands to mate with the 30-inch rail system used on the engine installation and transport trailers. Roller adapters supporting the engines on the trailers permit roll-transfer of the engine to the thrust stand without use of hoists, slings, or lifting devices. Figure 5-3 illustrates the transfer of the engine from the installation trailer to the M-37 test stand.

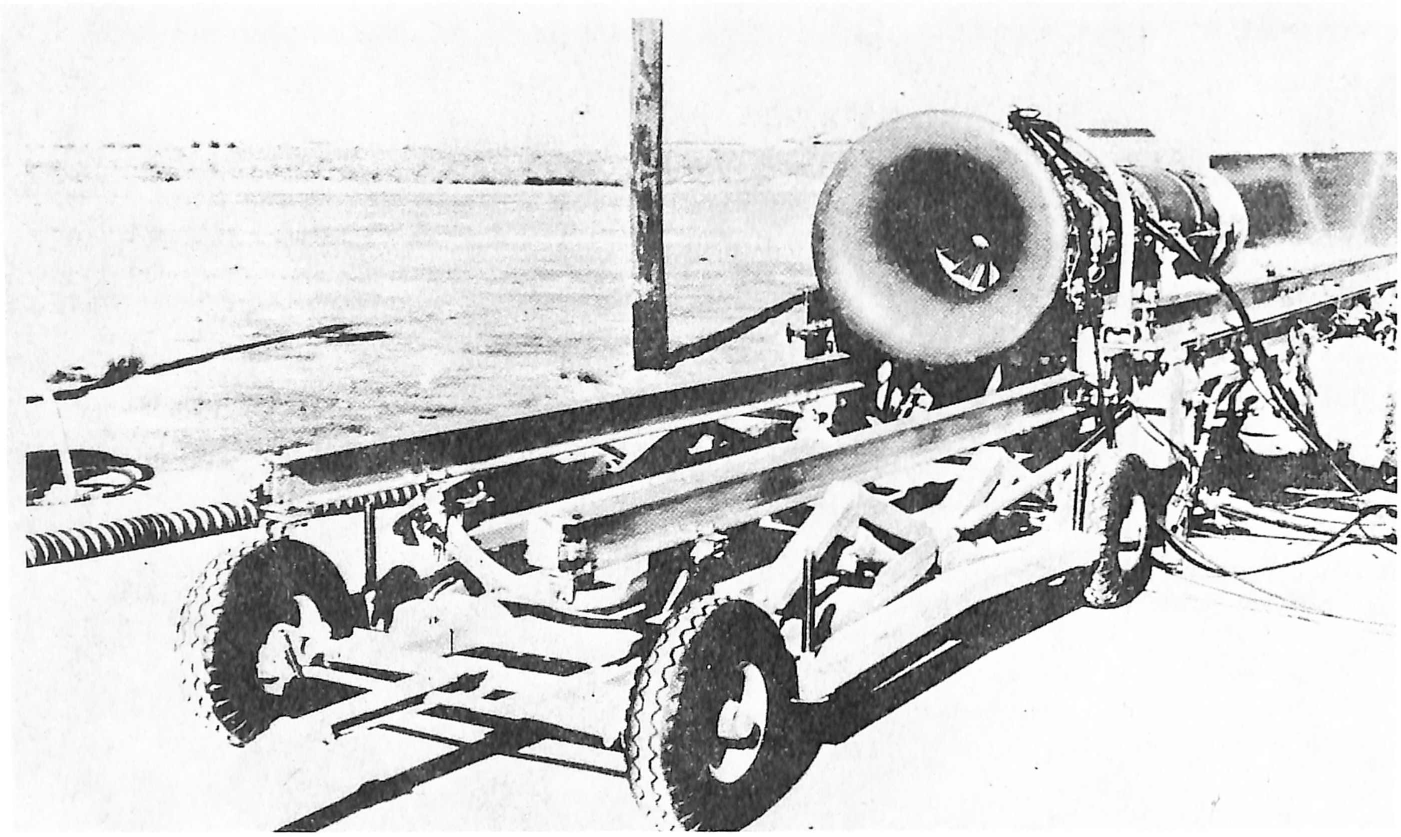


FIGURE 5-3. ENGINE TRANSFER TO TEST STAND

## Portable Engine Maintenance AGE

The three items of AGE shown in Figure 5-4 and Table 5-1 are collectively identified as the portable engine maintenance system. This system was developed to provide F-5E/F in-aircraft engine maintenance at the organizational maintenance level and to reduce the number of engine removals required for accessory replacement, engine rigging adjustment, or pilots' squawks.

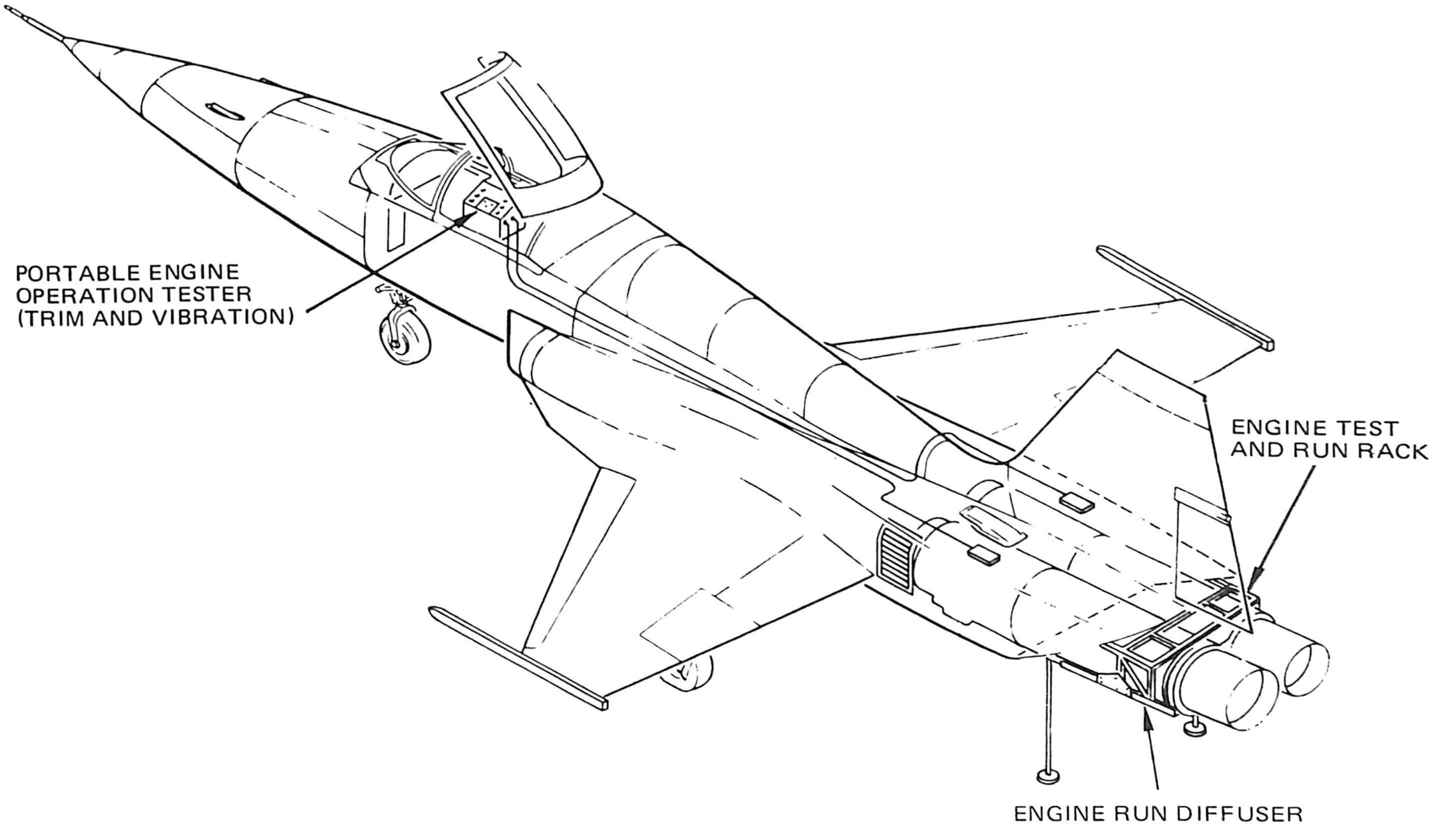

PORTABLE ENGINE OPERATION TESTER (TRIM AND VIBRATION)
ENGINE TEST AND RUN RACK
ENGINE RUN DIFFUSER

FIGURE 5-4. PORTABLE ENGINE MAINTENANCE SYSTEM

TABLE 5-1. PORTABLE ENGINE MAINTENANCE AGE

| PART NUMBER | NOMENCLATURE | FEDERAL STOCK NUMBER |
|---|---|---|
| A2258 | Portable Engine Operation Tester | 4920-825-1224 |
| 6-76203-1 | Engine Run Diffusers (2) | 4920-585-8959 |
| 3-76697-503 | Engine Test and Run Rack | 4920-492-5818 |

### Mobile Training Set

The Mobile Training Set (MTS) provides portable F-5E/F aircraft system training equipment consisting of maintenance trainers and technical training transparencies (TTT's) to support a complete maintenance training capability. The MTS supports instruction in the theory and methods of operation, identification and location of components, servicing, adjusting, troubleshooting, organizational and intermediate maintenance, and inspection of the components of the applicable systems. The separate trainers reflect individual systems and installations of the air vehicle.

The F-5E and F-5F MTS have, as the prime components of each system trainer, corresponding actual air vehicle component(s) installed in a manner that will permit adjustment or operation of the trainer system identical to the adjustment or operation of the system in the air vehicle.

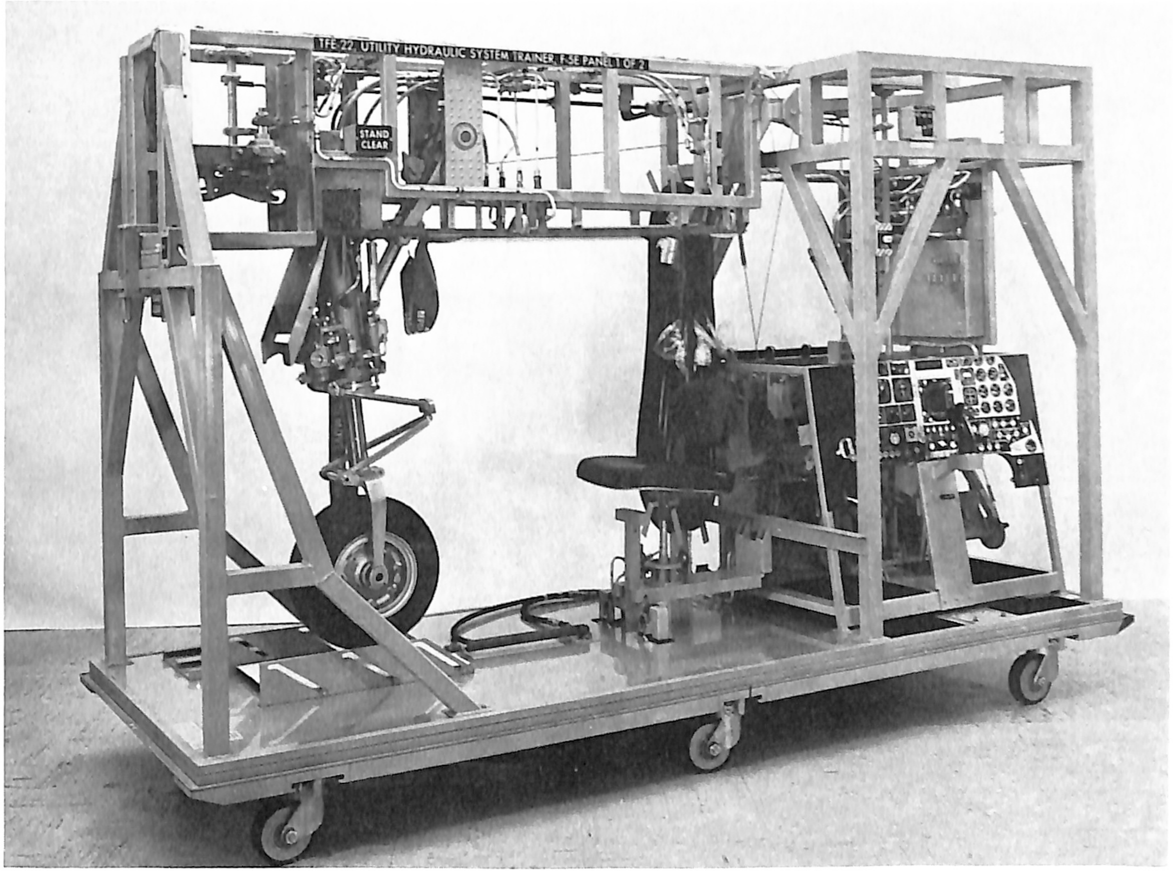
Each trainer is wired to conform to the actual aircraft, i.e., it duplicates numbered wiring and identification of junction boxes, panels, and connectors. Instruction in troubleshooting, adjusting, and calibrating is provided by test points that permit use of the same AGE as is used for the aircraft. Individual characteristics are identified in the following paragraphs.

Physical measurements for the complete F-5E MTS are:

| | |
|---|---|
| Weight: | Approximately 28,000 lb |
| Volume: | Approximately 3000 cu. ft. |

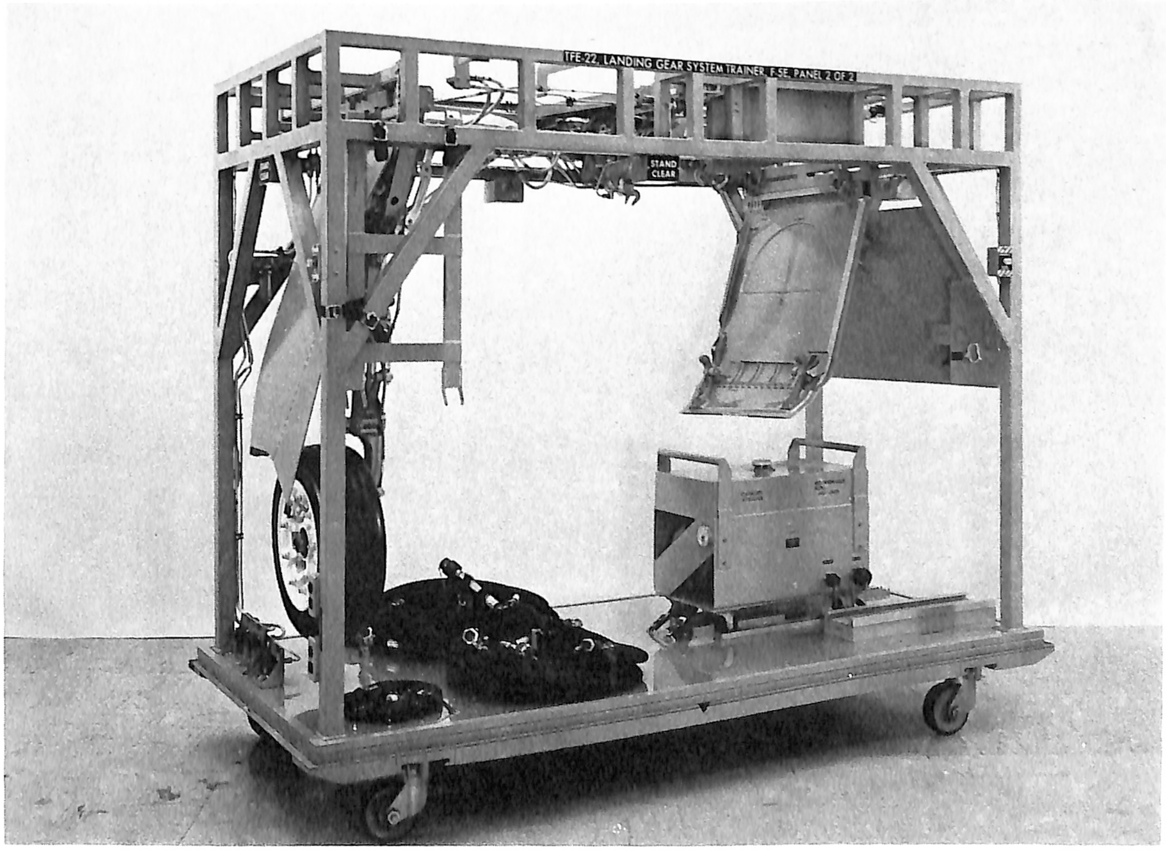
The individual trainers conform to the configuration and size limitations of Class 1, 3, 4, and 5 trainers as specified in MIL-T-6328H.

The training equipment has been designed to provide maximum system oriented training. MTS maintenance is accomplished in the same manner as the air vehicle, using air vehicle test equipment; the equipment is supported through the USAF supply system. Some typical F-5E trainers, panels and equipment are shown in Figures 5-5 through 5-10. Space does not permit a complete listing which can be found in the F-5E/F Support Planning Guide NB 74-55.


TFE-22, UTILITY HYDRAULIC SYSTEM TRAINER, F-5E PANEL 1 OF 2
STAND CLEAR

72-04119

FIGURE 5-5. NOSE LANDING GEAR SYSTEM TRAINER, PANEL 1


TFE-22, LANDING GEAR SYSTEM TRAINER, F-5E, PANEL 2 OF 2
STAND CLEAR

72-04116

FIGURE 5-6. MAIN LANDING GEAR SYSTEM TRAINER, PANEL 2

## Mobile Training Set

The Mobile Training Set (MTS) provides portable F-5E/F aircraft system training equipment consisting of maintenance trainers and technical training transparencies (TTT's) to support a complete maintenance training capability. The MTS supports instruction in the theory and methods of operation, identification and location of components, servicing, adjusting, troubleshooting, organizational and intermediate maintenance, and inspection of the components of the applicable systems. The separate trainers reflect individual systems and installations of the air vehicle.

The F-5E and F-5F MTS have, as the prime components of each system trainer, corresponding actual air vehicle component(s) installed in a manner that will permit adjustment or operation of the trainer system identical to the adjustment or operation of the system in the air vehicle.

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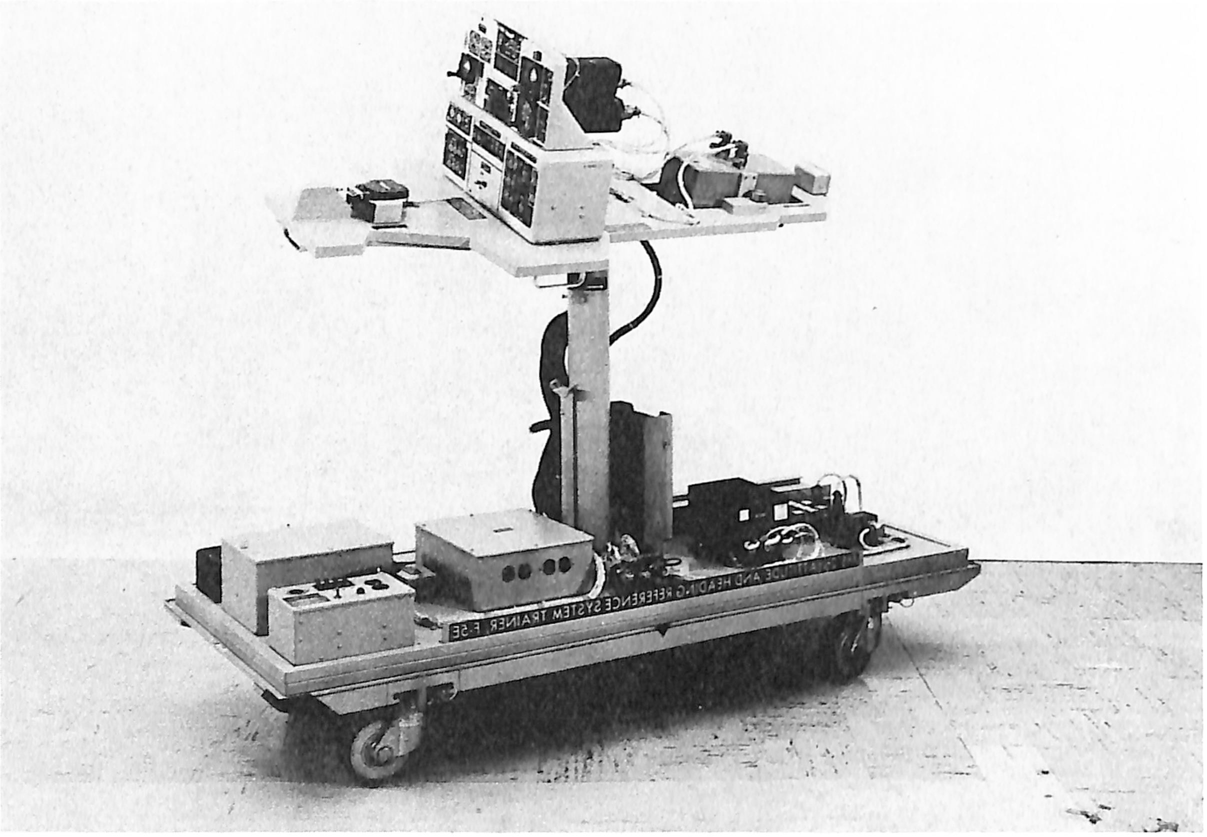
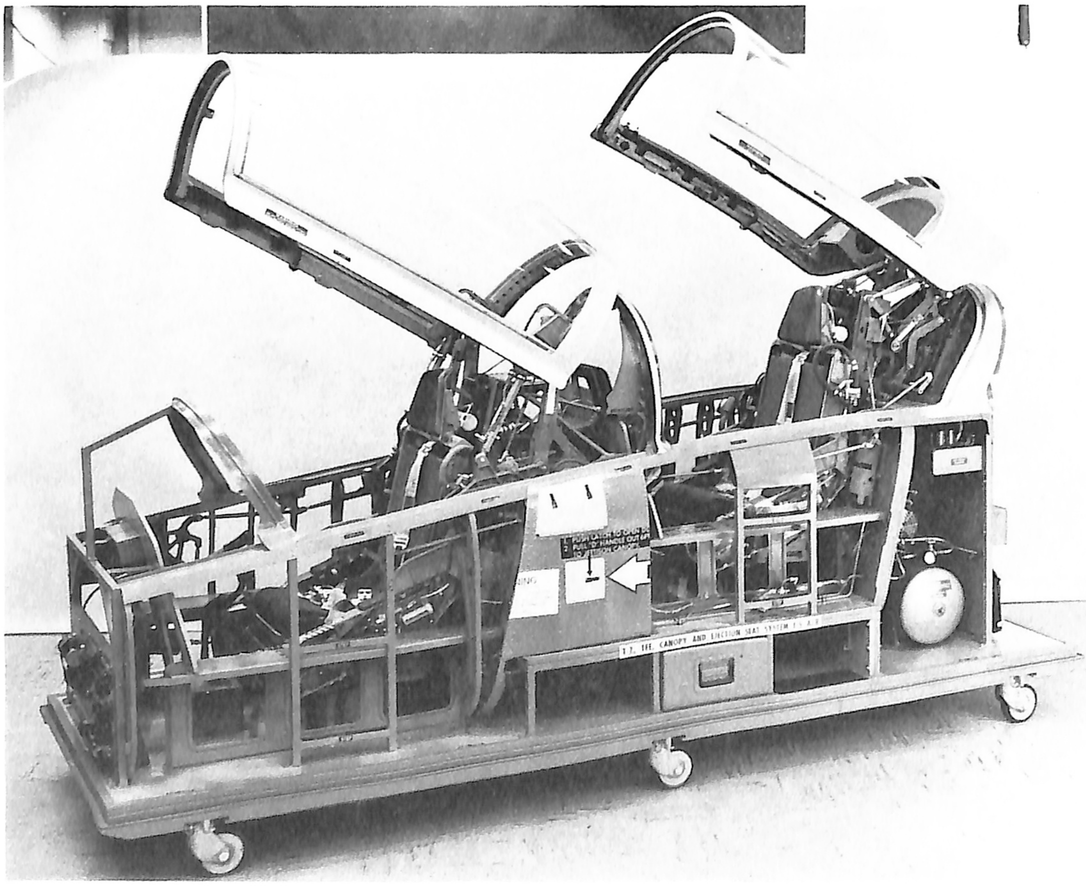


72-04129

FIGURE 5-7. ATTITUDE AND HEADING REFERENCE SYSTEM TRAINER



8062-113

FIGURE 5-8. CANOPY AND EJECTION SEAT SYSTEM TRAINER

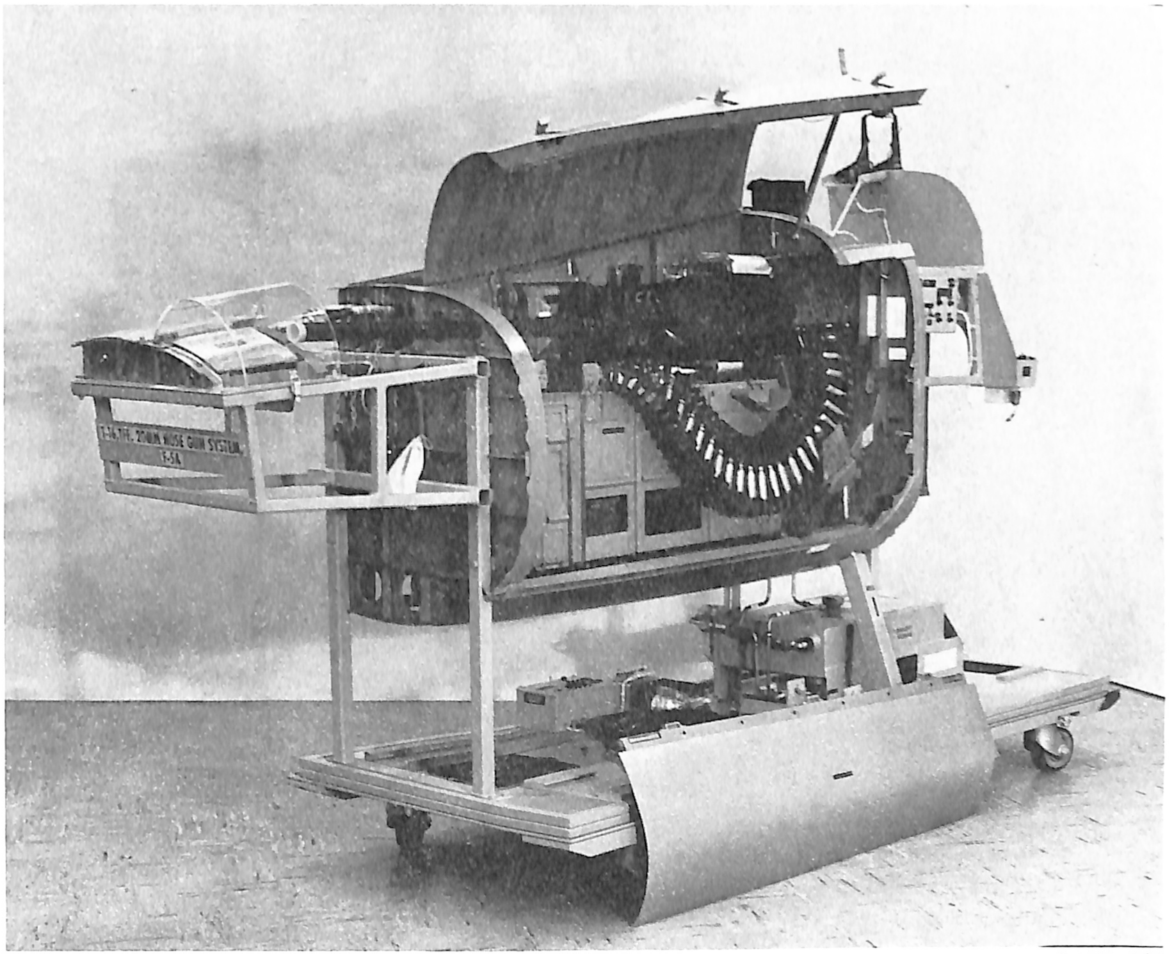

T-16 TFE. 20MM NOSE GUN SYSTEM
F-5A
8425-095

FIGURE 5-9. 20MM NOSE GUN SYSTEM TRAINER

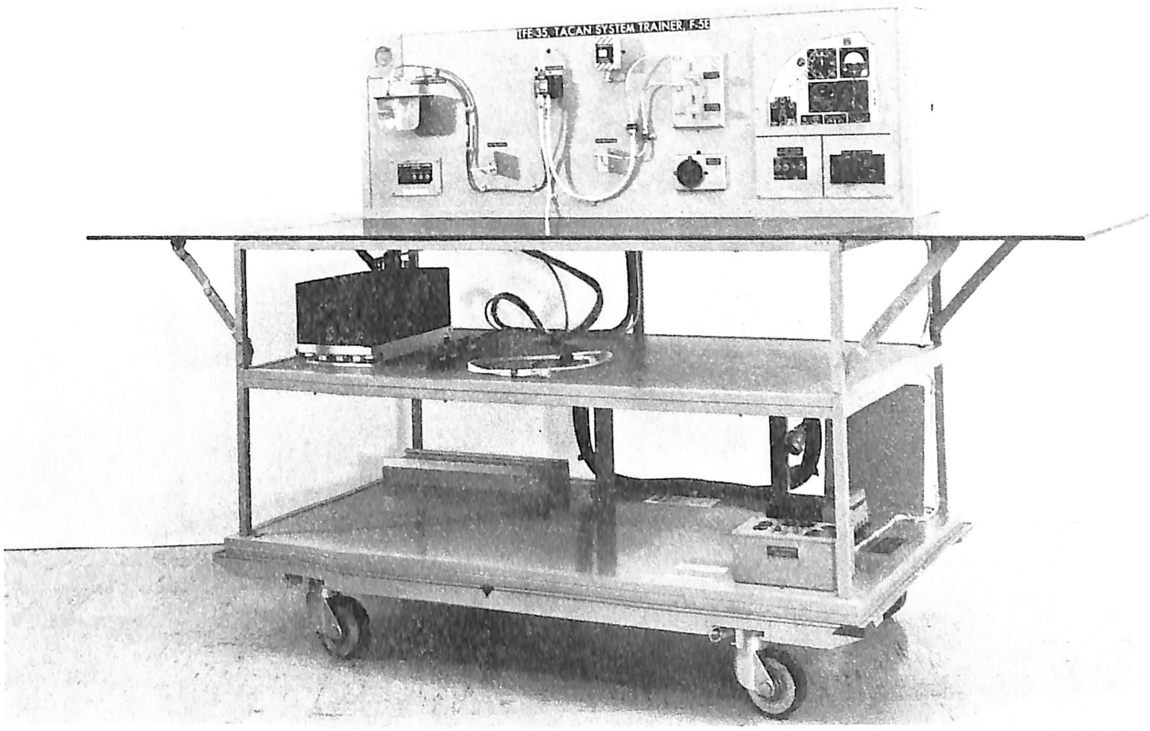

TFE-35. TACAN SYSTEM TRAINER, F-5E
72-04123

FIGURE 5-10. TACAN SYSTEM TRAINER

# APPENDIX A

# F-5E/F SYSTEM OPTIONS

# APPENDIX A

# F-5E/F SYSTEM OPTIONS

## INTRODUCTION

Appendix A presents the performance effects and engineering descriptions for the system options which can be obtained with the Northrop F-5E/F tactical fighter/trainer aircraft. The options presented have been contracted for on one or more models of the F-5E. Unless otherwise noted, all of the options are also feasible for the F-5F. However, not all have been contracted for on the F-5F airplane. Customers having an interest in or a requirement for options not included in this appendix, or for various option combinations, should contact Northrop directly regarding their adaptability to the F-5E/F airplanes. This appendix will be expanded as additional options for the airplanes are developed.

### Options List

- Assisted Takeoff (ATO)
- Photoreconnaissance System
- Air Refueling System
- External Tanks
- Jettisonable Pylons
- Multiple Ejector Rack
- Improved Northrop Escape System
- Inertial Navigation System
- Instrument Landing System/ Flight Director System
- Improved TACAN
- Low Frequency ADF
- VOR-ILS-DME System
- VHF Command Radio
- Alternate UHF Command Radio Set
- Alternate IFF/SIF System
- Radar Warning Receiver
- Maverick Missile Capability
- Improved Fire Control System

## ASSISTED TAKEOFF (ATO)

The F-5E ATO installation (Figure A-1) consists of the wiring, controls and a jettisonable rack capable of carrying two or four 15KS-1000 ATO bottles. Each bottle provides a net thrust of 1000 pounds for approximately 15 seconds. The ATO rack, when installed, is attached by externally-mounted removable fittings to the lower fuselage between Fuselage Stations 388.75 and 428. Rack support-fittings are attached to the fuselage tunnel beams. Installed weight of the four-bottle ATO system, prior to lightoff, is 639 pounds of which 635 pounds is jettisonable. Ignition and jettison of the rack and ATO bottles is controlled electrically from the cockpit. Jettison is accomplished by means of an explosive bolt that allows airloads and gravity to separate the rack from the airplane. Airspeed is limited to 350 KIAS until the rack is jettisoned. The rack cannot be jettisoned with the weight of the aircraft on the main landing gear. The ATO ignition and jettison system circuits are powered by the 28-volt dc bus. The location of the controls and indicators is shown in Figure A-2.

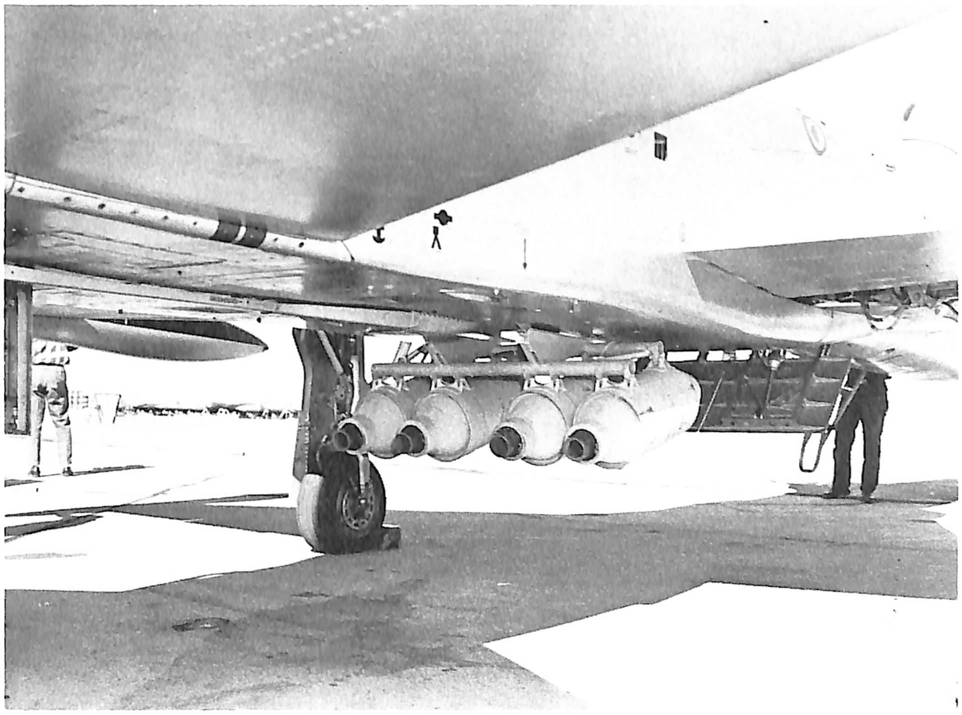


FIGURE A-1. ATO INSTALLATION

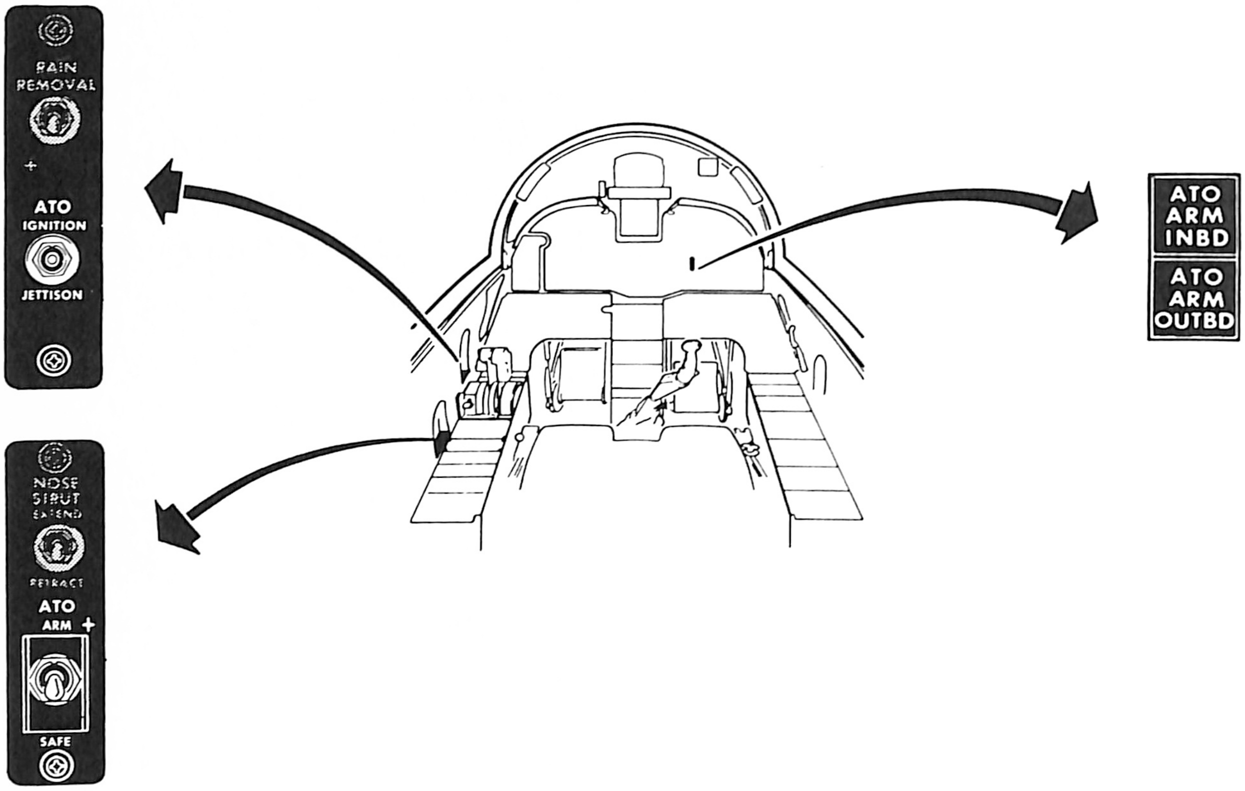

RAIN
REMOVAL
ATO
IGNITION
JETTISON
NOSE
STRUT
EXTEND
RETRACT
ATO
ARM
SAFE
ATO
ARM
INBD
ATO
ARM
OUTBD

FIGURE A-2. F-5E ATO SYSTEM CONTROLS AND INDICATORS

Airplane trim effects at burnout, which usually takes place above the fifty-foot altitude point, are small and easily controllable. The system has been used sucessfully for several years on the Norwegian F-5 airplanes.

The effects of two and four bottles on takeoff performance are shown for the F-5E in Figure A-3. At a maximum takeoff weight of 24,018 pounds, the sea level takeoff ground roll with four bottles is reduced by 1200 feet or 25 percent and the total distance over a 50-foot obstacle by 2100 feet or 30 percent. The cruise performance effects of the external fittings and internal provisions of the ATO installation which remain after the bottles and the rack have been jettisoned are negligible. The added weight after bottle-and-rack jettison is four pounds.

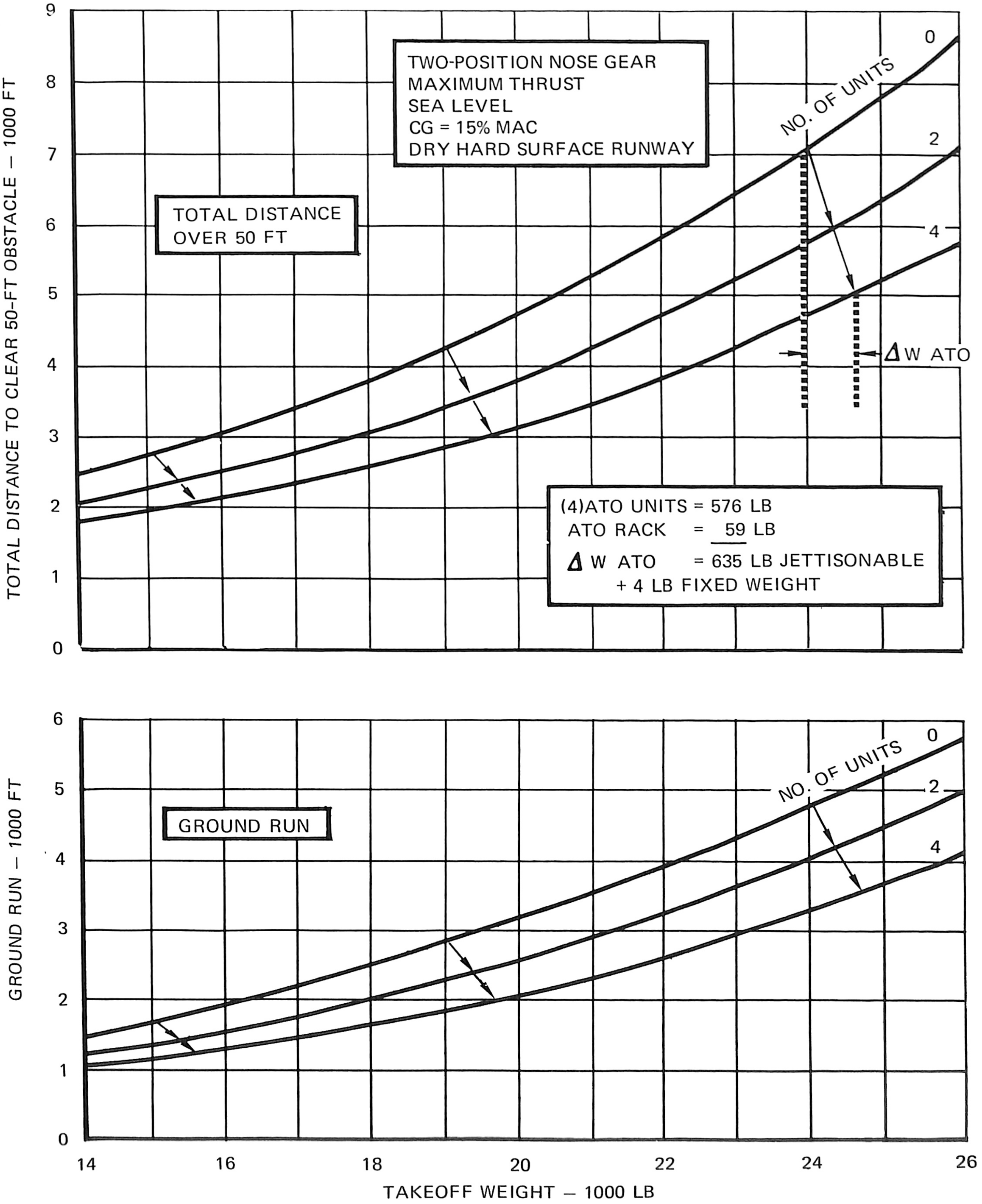
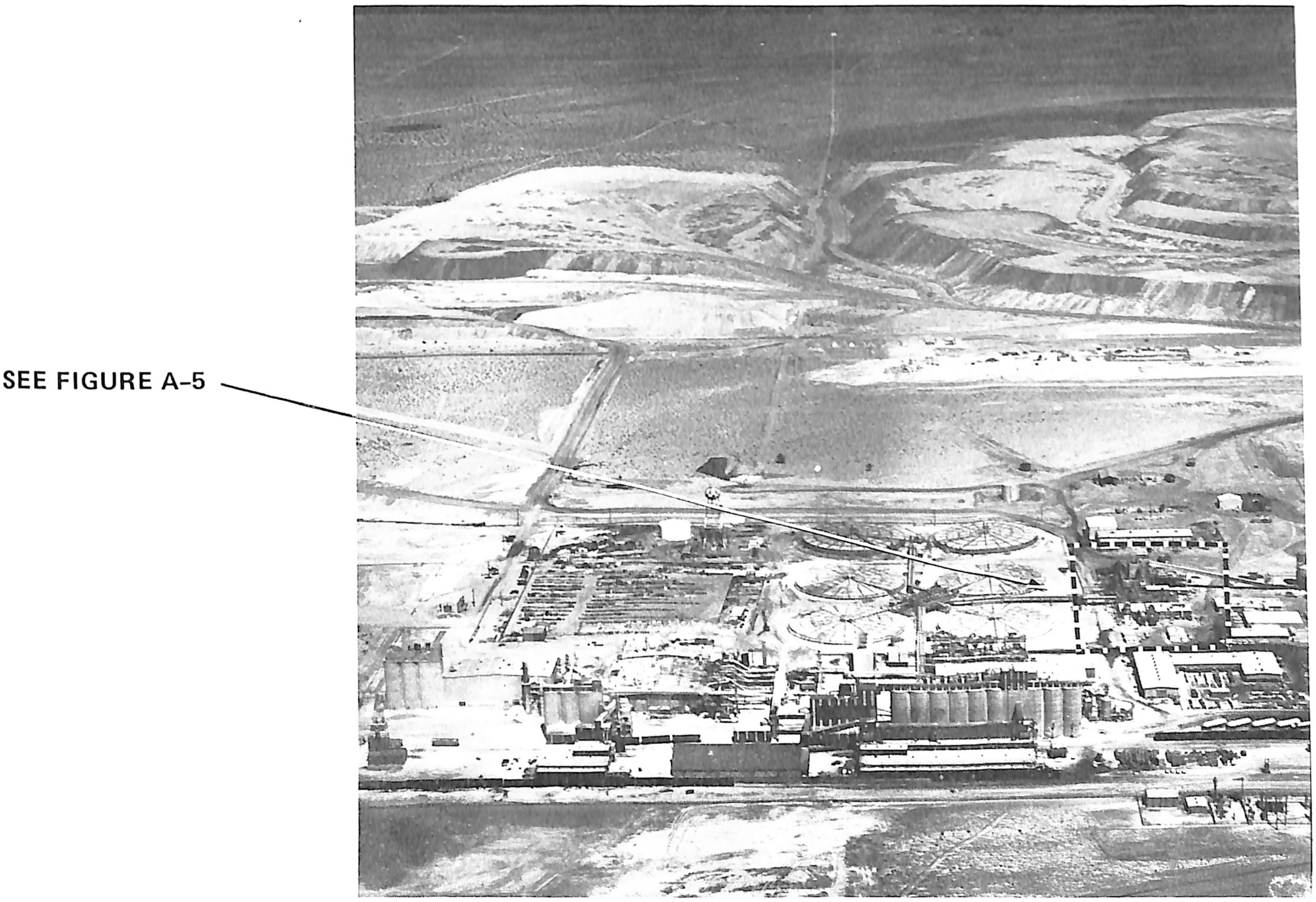


FIGURE A-3. F-5E TAKEOFF PERFORMANCE WITH ATO

## PHOTORECONNAISSANCE SYSTEM

The F-5E KS-121A Photoreconnaissance System is designed to permit a wide range of daylight applications ranging from photographic police missions conducted against political insurgents, to strike damage assessment in a hostile environment. The F-5E (Recon)* equipped with an internally-mounted 70mm framing camera array, also retains the full firepower provided by the 20mm nose guns and AIM-9 missiles as well as the performance and tactical flexibility of the F-5E tactical fighter. The F-5E Photoreconnaissance System applies the excellent stability and low speed maneuvering qualities of the F-5E to provide an airborne camera platform, capable of producing high resolution intelligence photos for a variety of operational conditions (Figures A-4 and A-5).



CAMERA: FORWARD OBLIQUE LENS: 6 INCH f2.8 PACIFIC OPTICAL
ALTITUDE: 1300 FEET AIRSPEED: 525 KNOTS (0.80 MACH)
ACTUAL NEGATIVE SIZE: 70MM (PICTURE SIZES REDUCED BECAUSE OF SPACE LIMITATIONS)

FIGURE A-4. F-5E KS-121A CAMERA SYSTEM PHOTOGRAPH OF BORAX PLANT, BORON CALIFORNIA – 4.8 X ENLARGEMENT

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*The photoreconnaissance system is provided as an end item with two-way interchangeability provisions between the standard radar nose and the recon nose. The designation RF-5E is not used. An F-5F system is being developed.

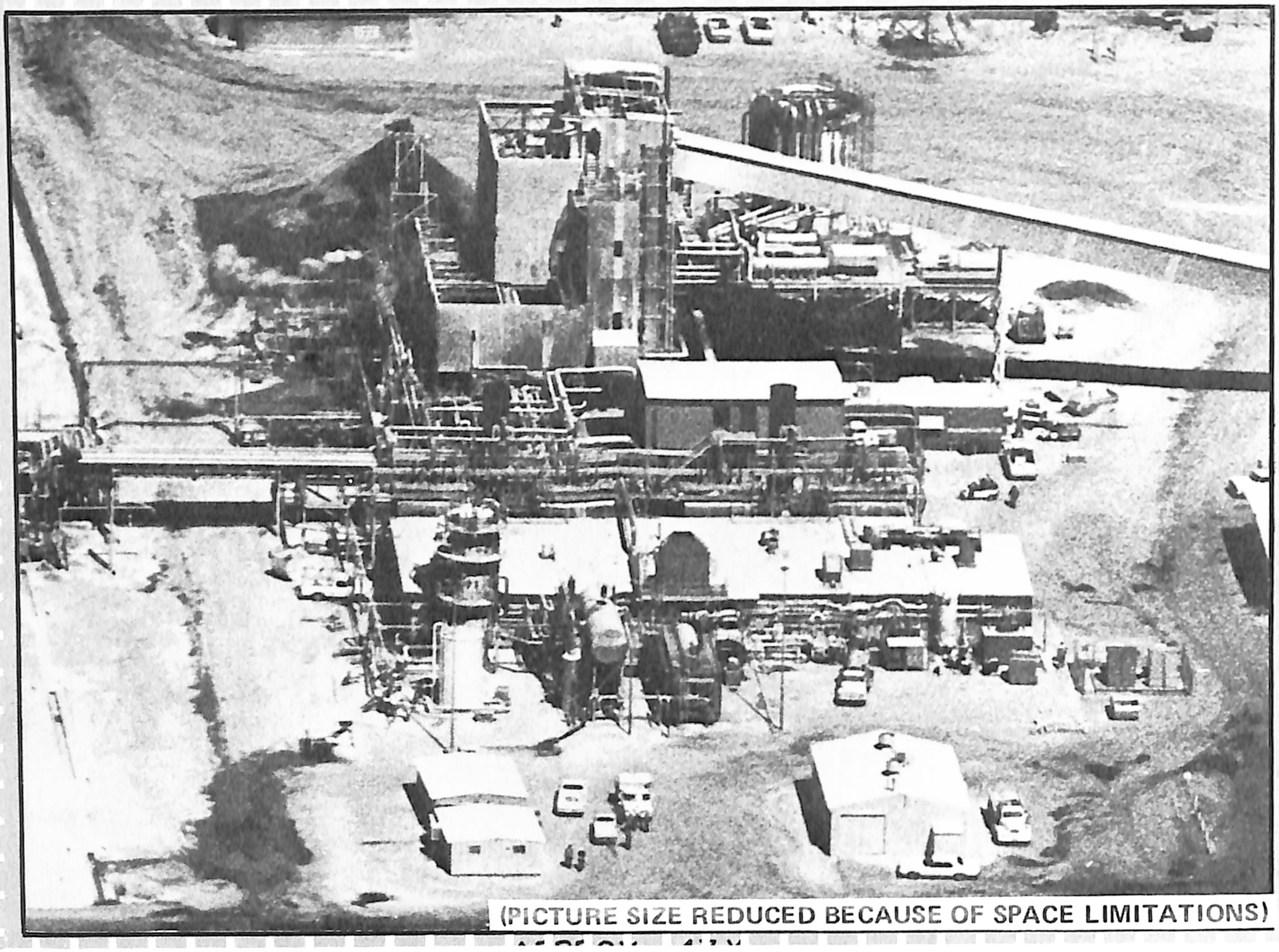


FIGURE A-5. F-5E KS-121A CAMERA SYSTEM PHOTOGRAPH FROM DASHED LINE OUTLINE AREA OF FIGURE A-4 – 47 X ENLARGEMENT

The reconnaissance nose section contains four KS-121A 70mm pulse framing cameras arranged in three tandem bays. The bays includes forward-oblique camera, left and right oblique and vertical camera which can be arranged in six different split vertical or standoff arrangements of three or four cameras each. The cameras employ automatic exposure control, computed by individual through-the-lens light sensors within each camera. Pulse rates are controlled by the pilot, who also selects the camera, or group of cameras, required during the mission. Installation of the reconnaissance nose section necessitates removal of the radar antenna and, consequently, all radar LRU's are removed. The lead computing sight is retained but utilizes fixed range of 1500 ft and range rate of 150 ft/sec. for the computation of lead angle.

The KS-121A camera system is a fully operational daylight photoreconnaissance system. A nighttime KS-121 camera system is under development by Chicago Aerial Industries (CAI).

In addition to military reconnaissance, the F-5E KS-121A photoreconnaissance system can be used for many peacetime applications:

- Water pollution surveys
- Agricultural and forestry surveys
- Insect damage - agriculture or forests
- Earth resources surveys
- Hydrology and water resources surveys
- Land development studies
- Natural disaster evaluation - earthquake, flood, fire, storm
- Wildlife inventories
- Landform and soil analysis

### Camera Installation

The camera installation, located in a special structure which replaces the F-5E nose section forward of Fuselage Station 90, incorporates several significant features, designed to minimize turnaround time on operational missions and to substantially decrease the maintenance time ordinarily associated with airborne camera systems.

The photoreconnaissance nose, shown in Figures A-6 and A-7, uses two magnesium castings as the primary structural members; the aft (lower) casting is mounted rigidly to the Fuselage Station 90 bulkhead; the forward (upper) casting is attached to the aft casting by a beamwise hinge on the lower side of the nose. The aft casting contains all mounting provisions for cameras, including mounts, supports, and adapters, as well as five camera ports.

The hinged forward section of the nose contains the pitot-static boom and flexible lines routed aft to connect with rigid lines at Fuselage Station 70. The forward section contains the window for the forward oblique camera, and is secured in the closed position by quick-release, overcenter-type latches and shear pins located in the aft casting. It is held in the open position with an overcenter locking link which also serves as a friction brake during opening and closing of the section.

The camera mounting provisions permit the four cameras (and equipment) to be easily arranged for optimum photographic coverage on low or medium altitude missions and satisfactory coverage to 40,000 feet. Cast-in markings and color coding on the support brackets aid in minimizing the time required for installation or rearrangement of the cameras.

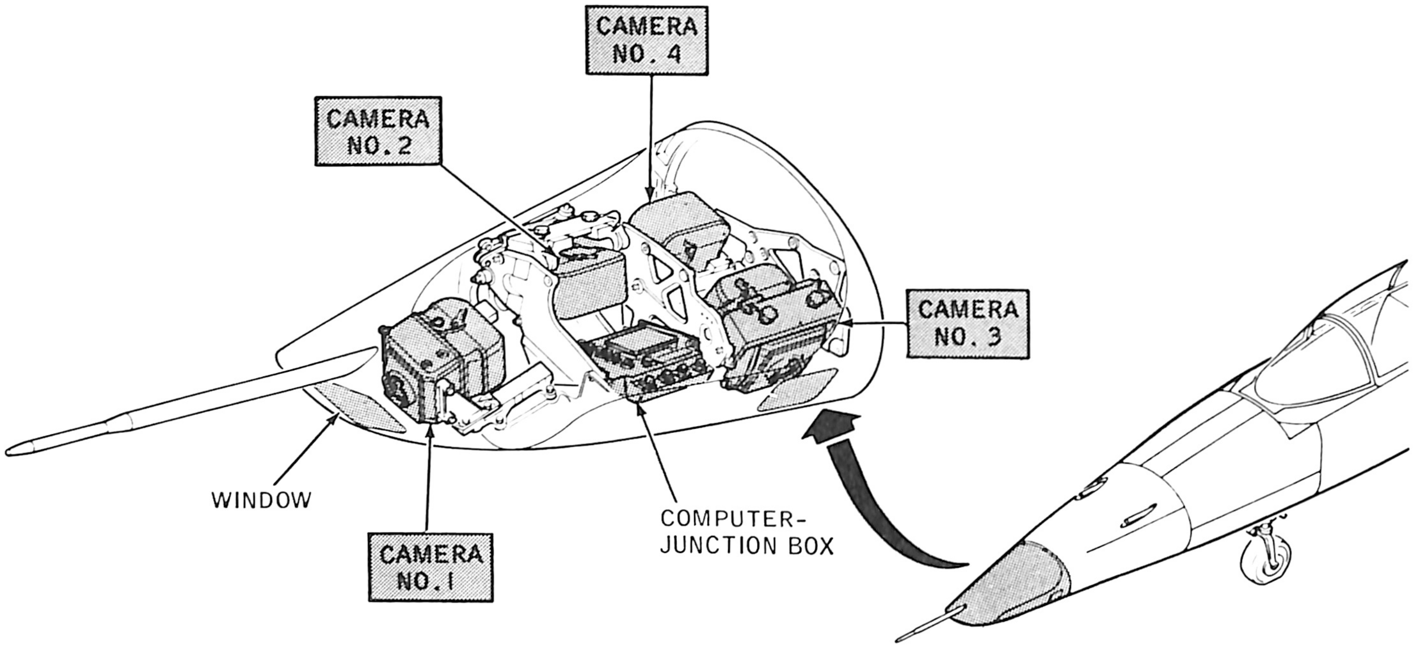

CAMERA NO.4
CAMERA NO.2
CAMERA NO. 3
WINDOW
CAMERA NO.1
COMPUTER-JUNCTION BOX

FIGURE A-6. F-5E RECONNAISSANCE NOSE

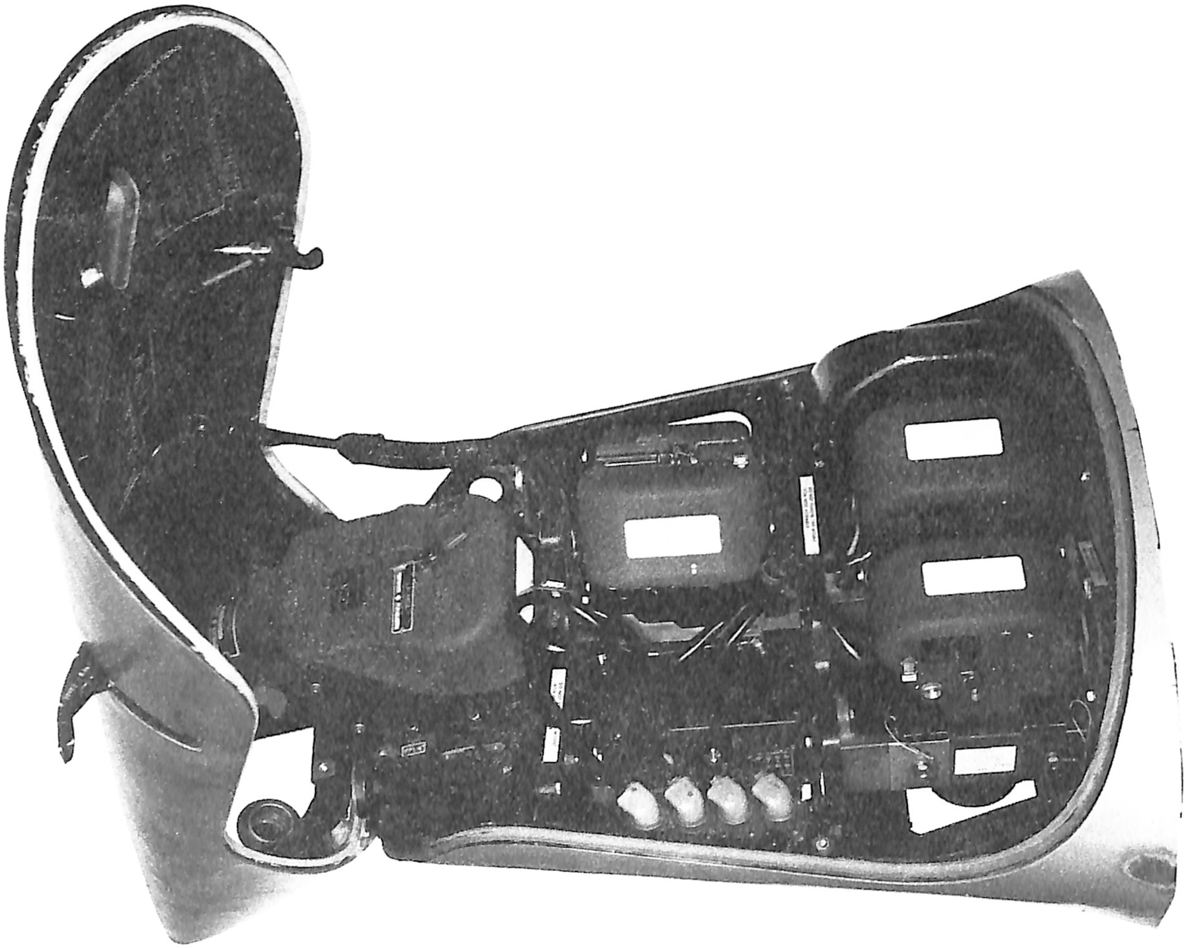


FIGURE A-7. CAMERA INSTALLATION

Each of the camera stations is equipped with a window fabricated from optical glass, and supplied with defog air through a system of ducts connected to the aircraft's conditioning system. The temperature in the camera section is controlled within a range of 50° to 90°F.

## Camera System

The KS-121A camera is manufactured by Chicago Aerial Industries Inc. (CAI). Each camera is fitted with a film magazine containing 200 feet of thin base (2.5 mils), double-perforated 70mm aerial film. The film magazine attaches to the camera body by means of overcenter latches which permit the magazine to be removed or replaced without removing the camera from its mounts. The film magazine accommodates a standard NATO film core.

The camera body incorporates several design features not generally available on 70mm cameras and system reliability is substantially increased. These special KS-121A features include new shutter design, vacuum film flattening and built-in-test (BIT) capability.

The KS-121A shutter is designed to eliminate the sticking, jamming, and bounce which occur at high cycling rates. The shutter operates under a spring load modified by the addition of a gear train and clutch which maintain a constant load on the mechanism. The constant load precludes deformation or jitter during operation of the shutter and results in constant density exposures, without bars of varying density on the film.

The KS-121A camera system has a mean-cycles-before failure (MCBF) of 29, 000 cycles and a service life of 100, 000 feet of film. Various types of Kodak 70mm panchromatic, IR and color film, are presented in Table A-1 to show the variety of film available for the KS-121A camera. Other film may be used provided it meets the MIL Std 33525 requirements for Type II perforations and the film base thickness is not less than 2.5 mils.

The KS-121A camera incorporates a vacuum pump inside the camera body. This pump creates a vacuum at the film platen, thereby forcing the film to maintain flatness in the plane of optimum focus. Improved flatness provides an increase of 10 to 20 percent in overall resolution compared with the previous cameras.

The control panel and computer junction box (CJB) for the KS-121A system includes a BIT button which energizes a test circuit in each camera. If the camera is in operable condition, lights on the cockpit control panel and CJB illuminate.

The automatic exposure control (AEC) system is based on readings taken during flight by sensors built into each camera. The AEC system allows the camera to be operated at the maximum shutter speed (1/4000 second) until the ambient light conditions cause the lens to open to the maximum aperture at which point the shutter speed is automatically reduced with reduced light conditions. Shutter speed is infinitely varied between 1/4000 and 1/250 second as the light conditions change.

TABLE A-1. FILMS FOR KS-121A CAMERA

| KODAK Film | Film Number | Sensitivity | Description and Applications |
|---|---|---|---|
| PLUS-X AEROGRAPHIC (ESTAR Base) | 2402 | Panchromatic (with extended red) | Medium-speed, high dimensional stability for aerial mapping and reconnaissance |
| TRI-X AEROGRAPHIC (ESTAR Base) | 2403 | | High-speed, high dimensional stability for aerial mapping and reconnaissance under low levels of illumination |
| DOUBLE-X AEROGRAPHIC (ESTAR Base) | 2405 | | Medium- to high-speed, standard film for mapping and charting; high dimensional stability |
| PANATOMIC-X Aerial (ESTAR Thin Base) | 3400 | | Intermediate-speed, high-contrast, medium- to high-altitude reconnaissance film; suitable for small-negative format |
| PLUS-X Aerial (ESTAR Thin Base) | 3401 | | Medium-speed, high-contrast, fine-grain, medium- to high-altitude reconnaissance film |
| High Definition Aerial (ESTAR Thin Base) | 3414 | | Thin base, slow-speed, high-definition film for high-altitude reconnaissance |
| Infrared AEROGRAPHIC (ESTAR Base) | 2424 | IR | Black-and-white film for reduction of haze effects, water location, vegetation surveys, and multispectral aerial photography |
| AEROCHROME Infrared (ESTAR Base) | 2443 | | False-color reversal film, high dimensional stability for vegetation surveys and camouflage detection |
| AEROCHROME Infrared (ESTAR Thin Base) | 3443 | | Similar to 2443 Film; thin base for high spool capacity and minimum storage space |
| AEROCOLOR Negative (ESTAR Base) | 2445 | Color | High-speed, color-negative film without integral masking for mapping and reconnaissance |
| AEROCHROME MS Film (ESTAR Base) | 2448 | | Color-reversal film for low- to medium-altitude aerial mapping and reconnaissance |
| Aerial Color (ESTAR Thin Base) | SO-242 | | Slow-speed, high-resolution color-reversal film for high-altitude reconnaissance |
| Aerial Color (ESTAR Ultra-Thin Base) | SO-255 | | Similar to SO-242; ultra-base for maximum spool capacity; high-resolution film for high-altitude reconnaissance |
| EKTACHROME EF AEROGRAPHIC (ESTAR Base) | SO-397 | | High-speed, color-reversal film for aerial mapping and reconnaissance |

System capability is additionally increased by incorporation of new lens designs. The Zeiss-made 1.5-inch f/4.5 lens is an improved version of the lens utilized in the RF-5A. The 3-inch lens is a new f/2.8 design by Leitz and the 6-inch f/2.8 lens is a recent development by the Pacific Optical division of CAI which exhibits extremely high resolution across the entire exposure area.

Each lens is fitted with its own lens cone and is interchangeable on all KS-121A camera bodies. The lenses may be utilized in the combinations shown in Figures A-8 through A-13.

## Camera Arrangements

The various possible camera arrangements are presented in Figures A-8 through A-13. These figures show the ground coverage for each camera and the optimum altitudes for each arrangement. These camera arrangements have been designed to provide optimum coverage at all altitudes from 200 feet to 10,000 feet and satisfactory coverage from 100 feet to 40,000 feet as noted on the figures.

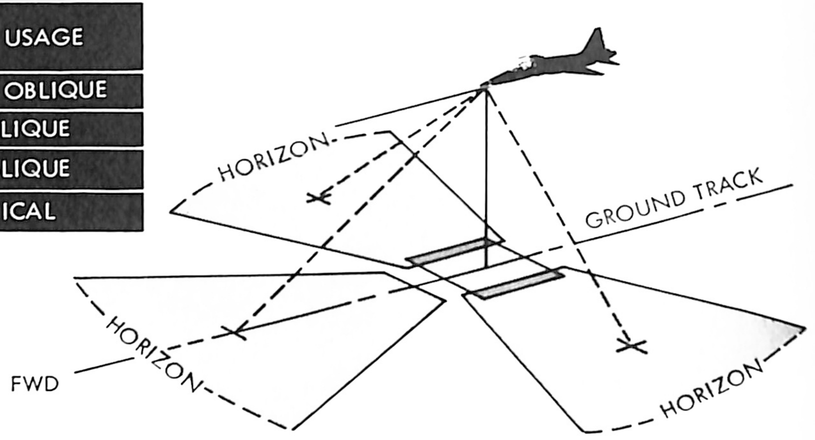
Vertical Stereo. If vertical stereo coverage is required, the Vertical Stereo — 60 Percent Overlap Coverage chart (Figure A-14) can be used as a guide. Vertical stereo coverage is vertical photographs of the same target area taken from slightly different angles. When the stereo (overlap) area is viewed through special stereo viewing equipment, targets show vertical development permitting more effective analysis. To use the chart, determine the size of the target and the scale required in the photography. Enter the chart with the scale and target size and determine first an altitude and lens focal length which will provide the required scale; second, the number of exposures required to cover the longest dimension of the target; and, third, the interval setting required between exposures at planned groundspeed. The length of the flight line to cover the long dimension will be determined by the number of exposures required and the other dimension of the target will determine whether additional flight lines are required. Generally, a 20-percent side-overlap between flight lines is considered satisfactory.

Stereo coverage requires 60 percent overlap from one exposure to the next, so that only 40 percent of each exposure is actual ground advance. The intervals in Figure A-14 will provide optimum stereo overlap. A greater than 60 percent overlap is usually acceptable but uses more film.

| FOUR CAMERAS | | | |
|---|---|---|---|
| CAMERA NUMBER | FOCAL LENGTH — INCHES | DEPRESSION ANGLE — DEGREES | USAGE |
| 1 | 3 OR 6 | 18 | FWD OBLIQUE |
| 2 | 1.5 | 26 | R OBLIQUE |
| 3 | 1.5 | 26 | L OBLIQUE |
| 4 | 1.5 | 90 | VERTICAL |

OPTIMUM ALTITUDE — 500 TO 1500 FEET

SATISFACTORY COVERAGE
FROM 100 TO 5000 FEET


HORIZON
GROUND TRACK
HORIZON
FWD
HORIZON

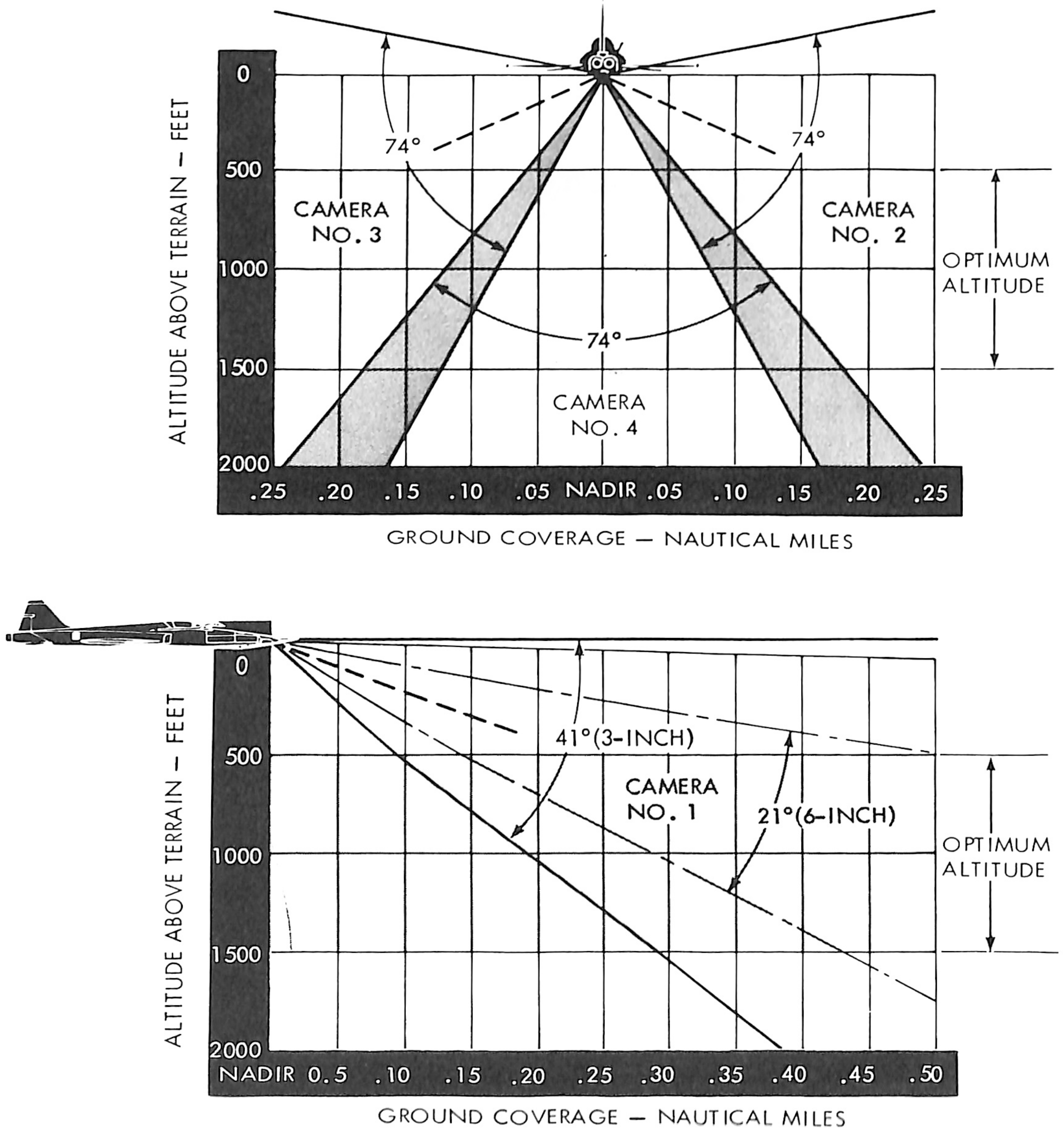
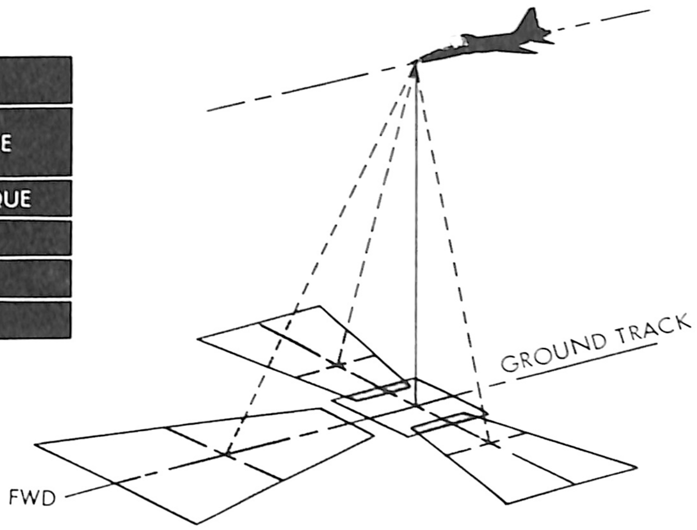


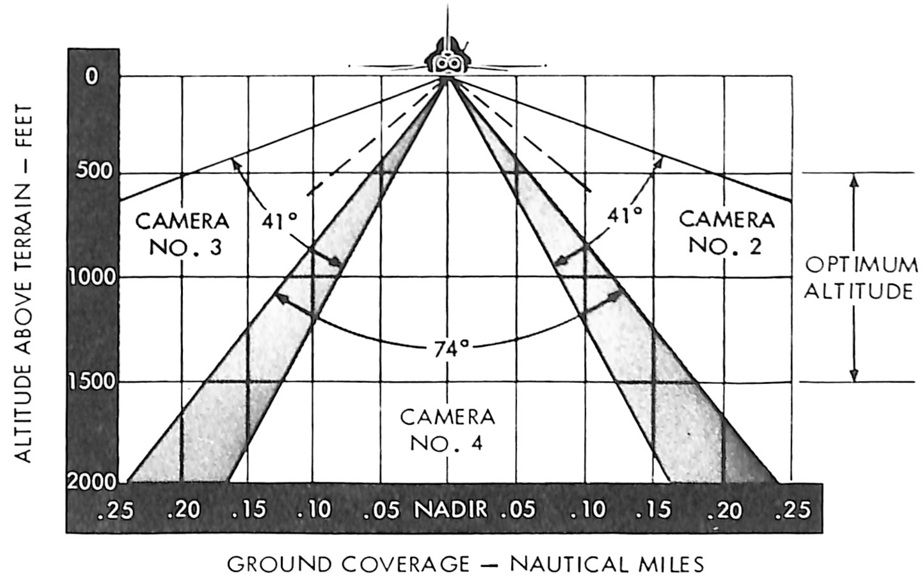
FIGURE A-8. CAMERA AREA COVERAGE ARRANGEMENT NO. 1

| FOUR CAMERAS | | | |
|---|---|---|---|
| CAMERA NUMBER | FOCAL LENGTH — INCHES | DEPRESSION ANGLE — DEGREES | USAGE |
| 1 | 3 OR 6 | 18 | FWD OBLIQUE |
| 2 | 3 | 41.5 | R OBLIQUE |
| 3 | 3 | 41.5 | L OBLIQUE |
| 4 | 1.5 | 90 | VERTICAL |

OPTIMUM ALTITUDE - 500 TO 1500 FEET

SATISFACTORY COVERAGE
FROM 100 TO 5000 FEET





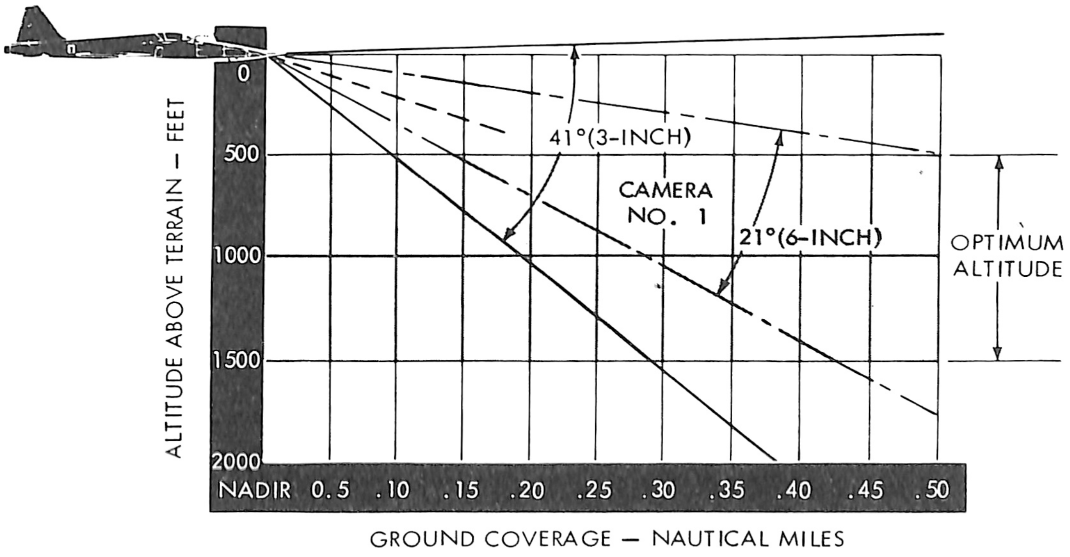
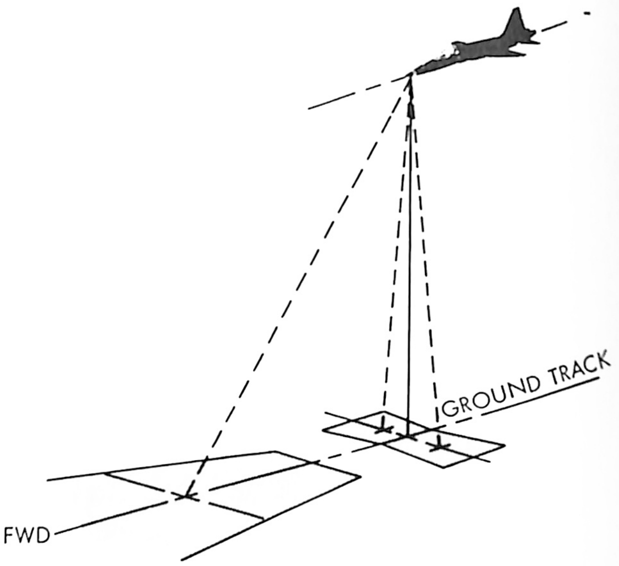


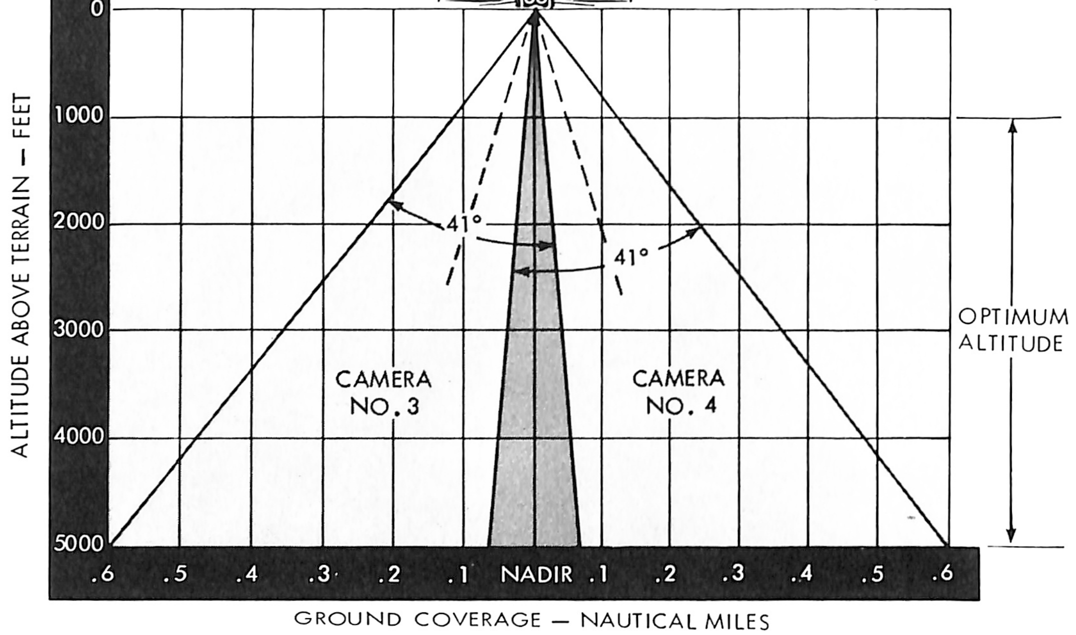
FIGURE A-9. CAMERA AREA COVERAGE ARRANGEMENT NO. 2

| SPLIT VERTICAL | | | |
|---|---|---|---|
| CAMERA NUMBER | FOCAL LENGTH — INCHES | DEPRESSION ANGLE — DEGREES | USAGE |
| 1 | 3 OR 6 | 18 | FWD OBLIQUE |
| 2 | — | — | NOT USED |
| 3 | 3 | 74 | SPLIT VERTICAL |
| 4 | 3 | 74 | SPLIT VERTICAL |

OPTIMUM ALTITUDE - 1000 TO 5000 FEET

SATISFACTORY COVERAGE
FROM 500 TO 20,000 FEET





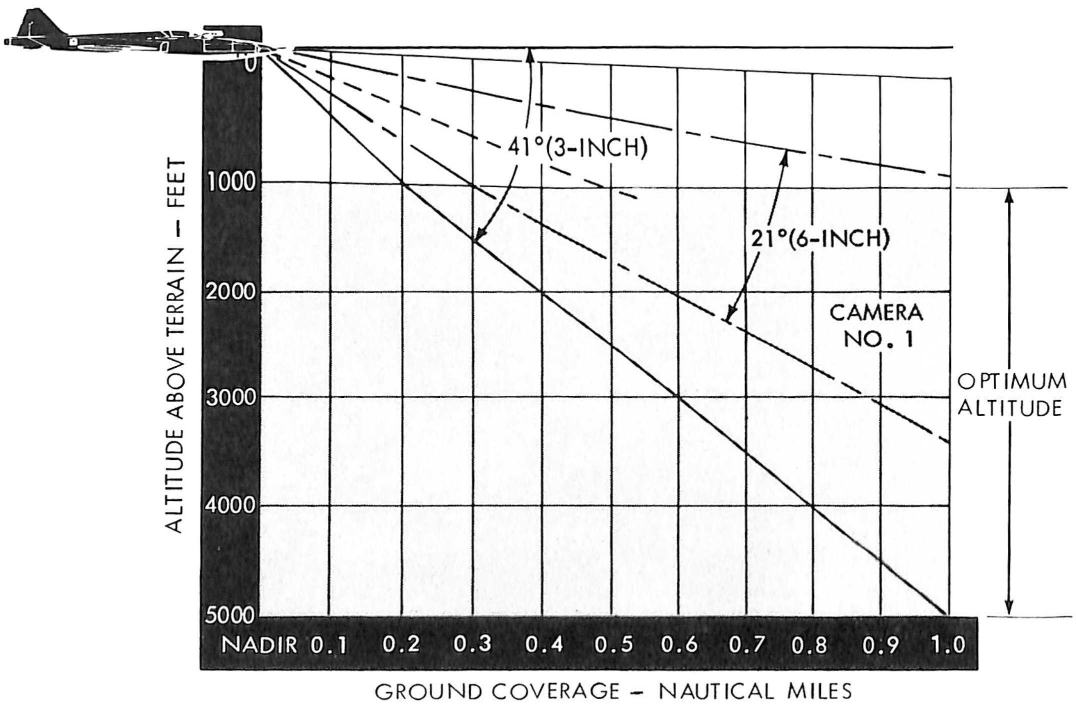
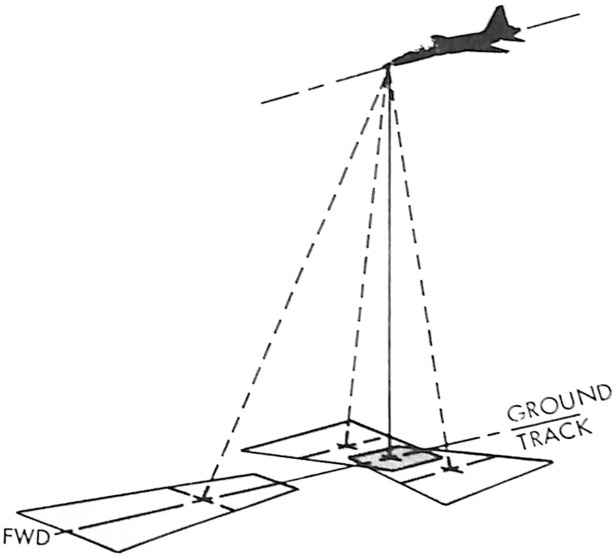


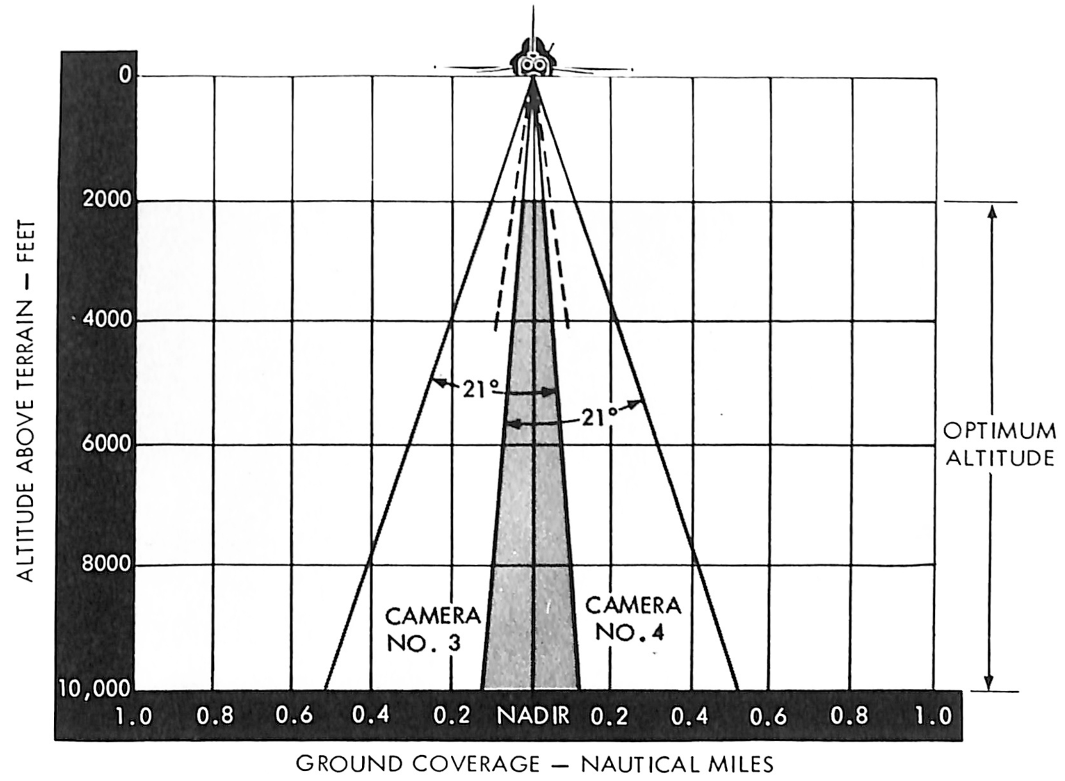
FIGURE A-10. CAMERA AREA COVERAGE ARRANGEMENT NO. 3

| SPLIT VERTICAL | | | |
|---|---|---|---|
| CAMERA NUMBER | FOCAL LENGTH — INCHES | DEPRESSION ANGLE — DEGREES | USAGE |
| 1 | 6 | 18 | FWD OBLIQUE |
| 2 | — | — | NOT USED |
| 3 | 6 | 81.5 | SPLIT VERTICAL |
| 4 | 6 | 81.5 | SPLIT VERTICAL |

OPTIMUM ALTITUDE -2000 TO 10, 000 FEET

SATISFACTORY COVERAGE FROM 1000 TO 40,000 FEET





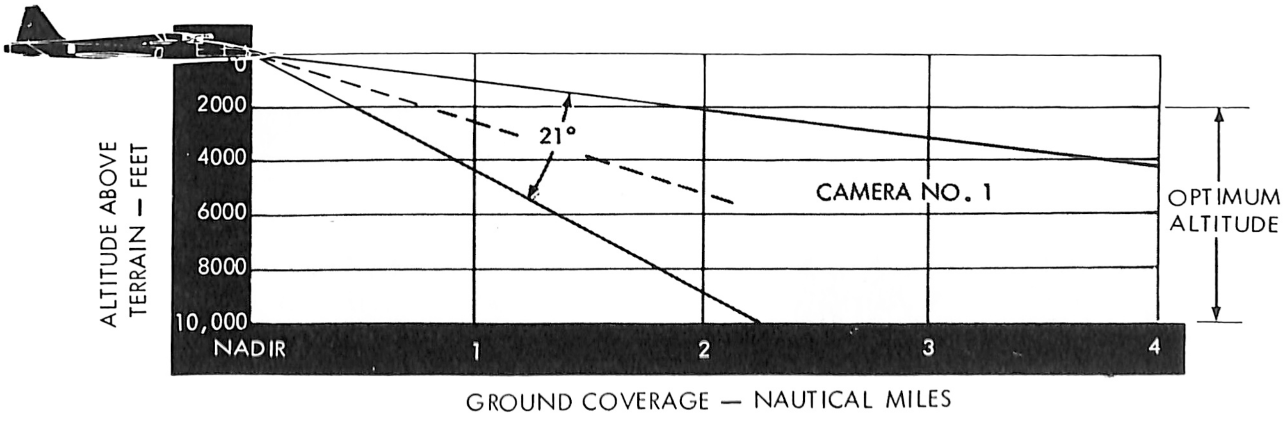
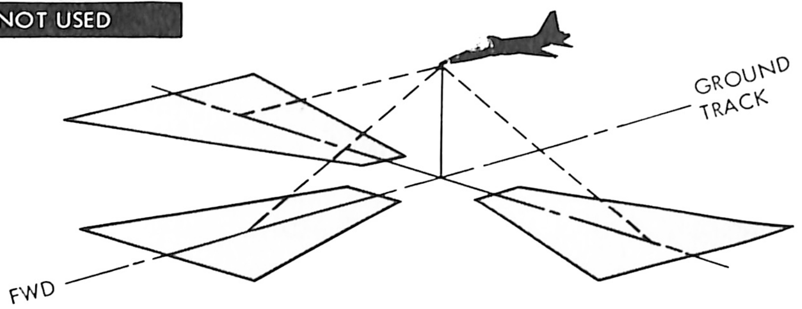


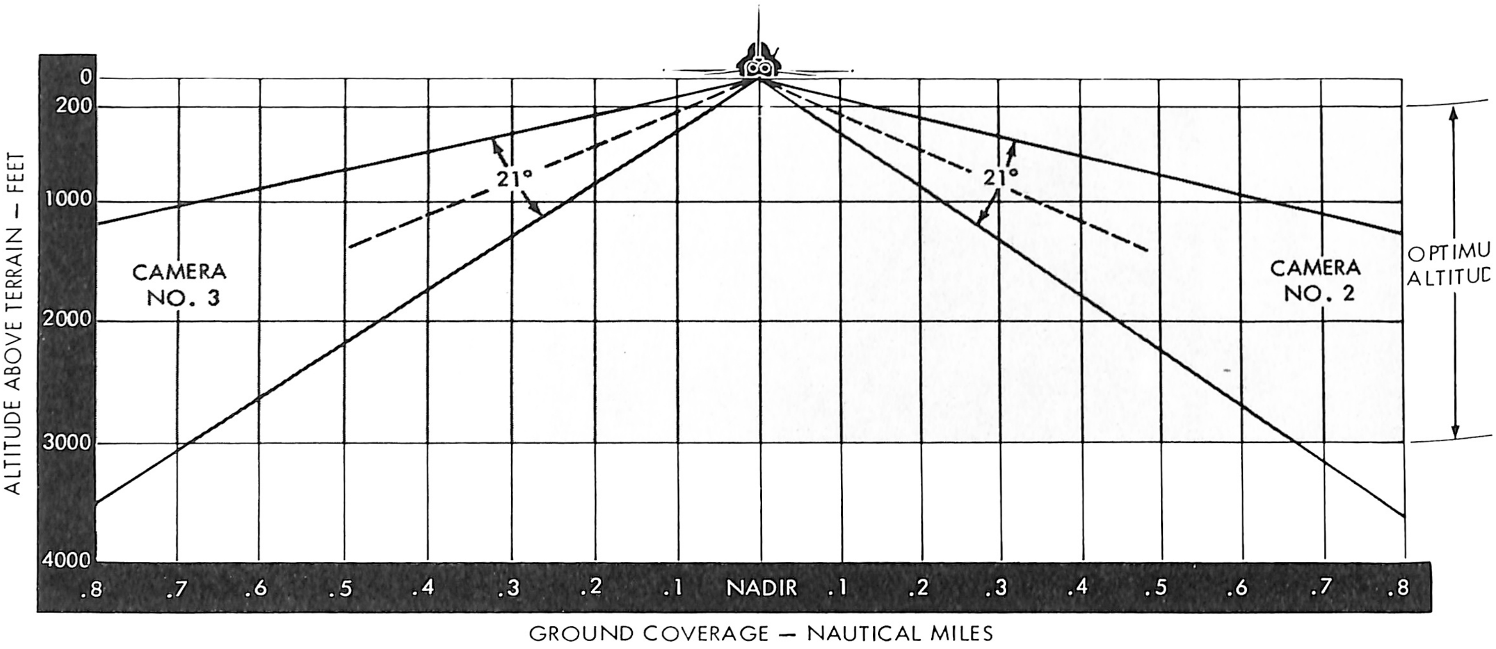
FIGURE A-11. CAMERA AREA COVERAGE ARRANGEMENT NO. 4

| SPLIT OBLIQUE | | | |
|---|---|---|---|
| CAMERA NUMBER | FOCAL LENGTH — INCHES | DEPRESSION ANGLE — DEGREES | USAGE |
| 1 | 3 OR 6 | 18 | FWD OBLIQUE |
| 2 | 6 | 25 | R OBLIQUE |
| 3 | 6 | 25 | L OBLIQUE |
| 4 | — | — | NOT USED |

OPTIMUM ALTITUDE - 200 TO 3000 FEET

SATISFACTORY COVERAGE
FROM 200 TO 20,000 FEET





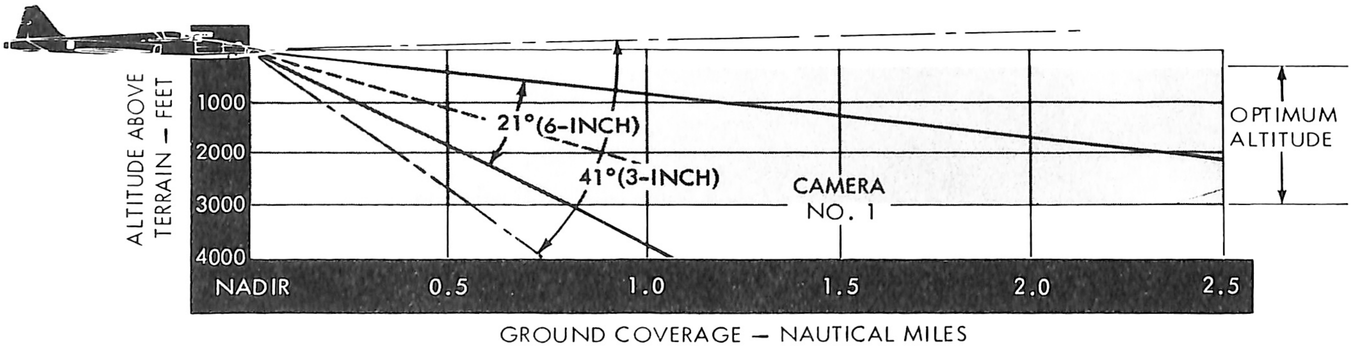
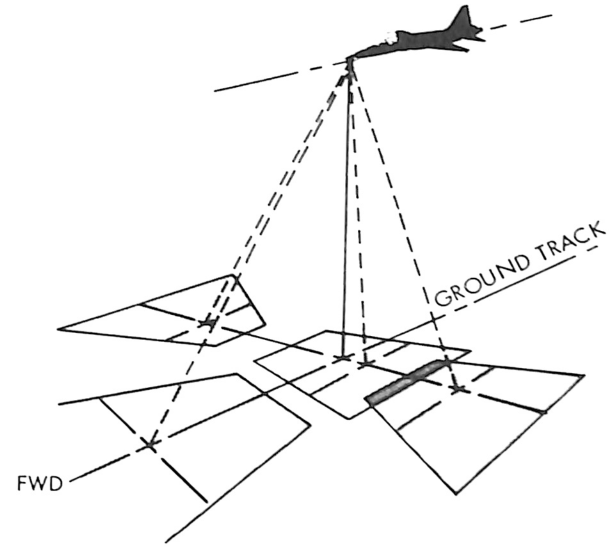


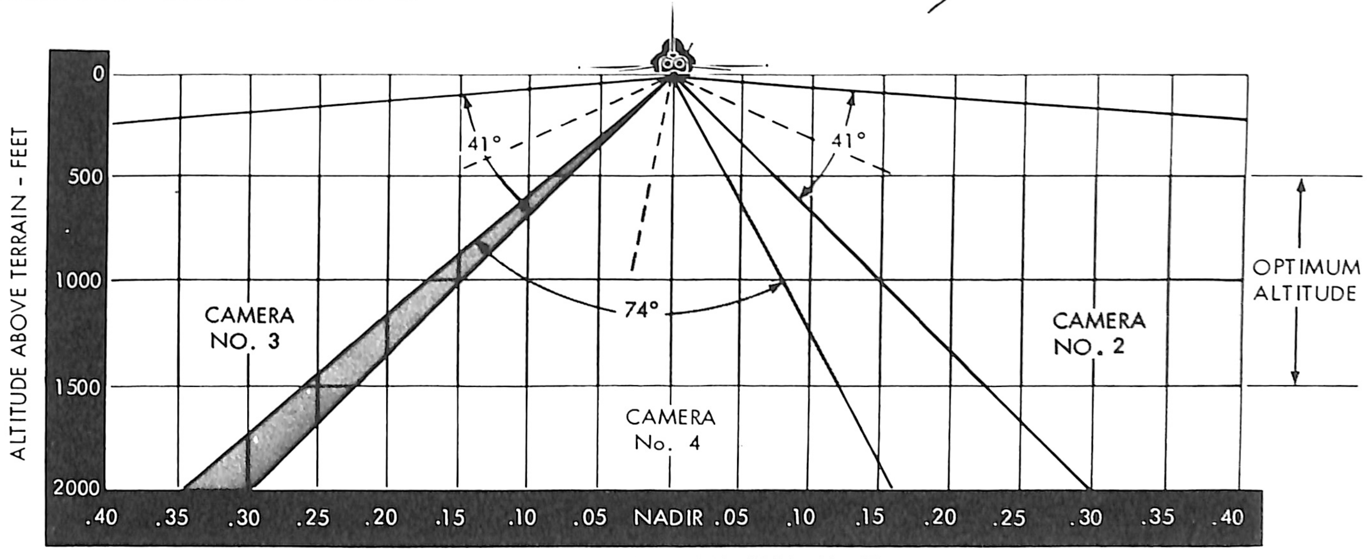
FIGURE A-12. CAMERA AREA COVERAGE ARRANGEMENT NO. 5

| LEFT OBLIQUE | | | |
|---|---|---|---|
| CAMERA NUMBER | FOCAL LENGTH – INCHES | DEPRESSION ANGLE – DEGREES | USAGE |
| 1 | 3 OR 6 | 18 | FWD OBLIQUE |
| 2 | 3 | 26 | R OBLIQUE |
| 3 | 3 | 26 | L OBLIQUE |
| 4 | 1.5 | 80 | VERTICAL |

OPTIMUM ALTITUDE - 500 TO 1500 FEET

SATISFACTORY COVERAGE FROM 100 TO 5000 FEET





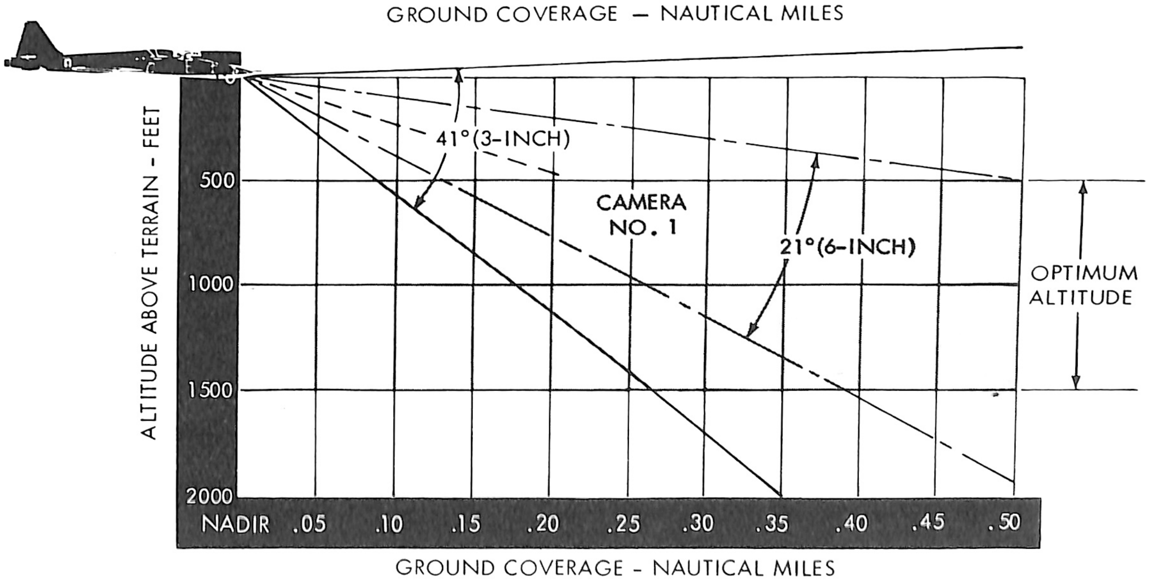
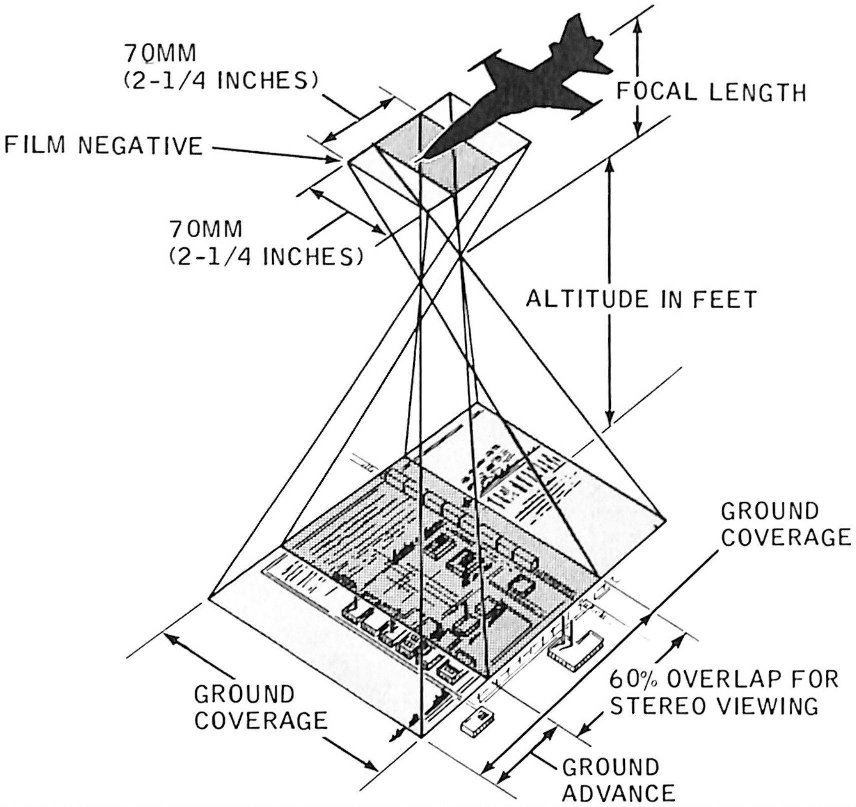


FIGURE A-13. CAMERA AREA COVERAGE ARRANGEMENT NO. 6


70MM
(2-1/4 INCHES)
FILM NEGATIVE
70MM
(2-1/4 INCHES)
FOCAL LENGTH
ALTITUDE IN FEET
GROUND
COVERAGE
GROUND
COVERAGE
60% OVERLAP FOR
STEREO VIEWING
GROUND
ADVANCE

| PHOTO SCALE | ABSOLUTE ALTITUDE – FEET | | | GROUND COVERAGE SINGLE FRAME | | INTVL-SEC SWITCH SETTING FOR GROUNDSPEED – KNOTS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LENS | | | | | | | | | | | |
| | 1.5-IN | 3.0-IN. | 6.0-IN. | FEET LINEAR | METERS LINEAR | 240 | 300 | 360 | 420 | 480 | 540 | 600 |
| 80,000 | 10,000 | 20,000 | 40,000 | 15,000 | 4,572 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| 40,000 | 5,000 | 10,000 | 20,000 | 7,500 | 2,286 | 6.0 | 6.0 | 5.0 | 4.0 | 4.0 | 4.0 | 3.0 |
| 36,000 | 4,500 | 9,000 | 18,000 | 6,750 | 2,057 | 6.0 | 6.0 | 5.0 | 4.0 | 4.0 | 3.0 | 3.0 |
| 32,000 | 4,000 | 8,000 | 16,000 | 6,000 | 1,829 | 6.0 | 5.0 | 4.0 | 4.0 | 3.0 | 3.0 | 3.0 |
| 28,000 | 3,500 | 7,000 | 14,000 | 5,250 | 1,600 | 6.0 | 5.0 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| 24,000 | 3,000 | 6,000 | 12,000 | 4,500 | 1,371 | 5.0 | 4.0 | 3.0 | 3.0 | 3.0 | 2.0 | 2.0 |
| 20,000 | 2,500 | 5,000 | 10,000 | 3,750 | 1,143 | 4.0 | 3.0 | 3.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| 18,000 | 2,250 | 4,500 | 9,000 | 3,375 | 1,029 | 4.0 | 3.0 | 3.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| 16,000 | 2,000 | 4,000 | 8,000 | 3,000 | 914 | 3.0 | 3.0 | 2.0 | 2.0 | 1.0 | 1.0 | 1.0 |
| 14,000 | 1,750 | 3,500 | 7,000 | 2,625 | 800 | 3.0 | 2.0 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 12,000 | 1,500 | 3,000 | 6,000 | 2,250 | 686 | 2.0 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 10,000 | 1,250 | 2,500 | 5,000 | 1,875 | 571 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 8,000 | 1,000 | 2,000 | 4,000 | 1,500 | 457 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1/2 |
| 6,000 | 750 | 1,500 | 3,000 | 1,125 | 343 | 1.0 | 1.0 | 1.0 | 1.0 | 1/2 | 1/2 | 1/2 |
| 5,000 | 625 | 1,250 | 2,500 | 937 | 286 | 1.0 | 1.0 | 1.0 | 1/2 | 1/2 | 1/2 | 1/3 |
| 4,000 | 500 | 1,000 | 2,000 | 750 | 229 | 1.0 | 1/2 | 1/2 | 1/3 | 1/3 | 1/3 | 1/4 |
| 3,000 | 375 | 750 | 1,500 | 562 | 171 | 1/2 | 1/2 | 1/3 | 1/3 | 1/4 | 1/4 | 1/5 |
| 2,000 | 250 | 500 | 1,000 | 375 | 114 | 1/3 | 1/3 | 1/4 | 1/5 | R | R | R |
| 1,480 | 185 | 370 | 740 | 281 | 93 | 1/4 | 1/5 | R | R | R | R | R |
| 1,000 | 125 | 250 | —— | 187 | 57 | R | R | R | R | R | R | R |

R = RUNAWAY (0.17-SECOND INTERVAL)

FIGURE A-14. VERTICAL STEREO – 60% OVERLAP COVERAGE

Computer Junction Box (CJB). The KS-121A system major electronic components are located in the CJB (Figure A-6). The CJB contains six printed circuit (PC) boards, four of which are interchangeable. Each of the four interchangeable PC boards contains all of the electronics associated with a single camera. The CJB also contains the intervalometer, the system power supplies and the BIT logic. The intervalometer is adjusted on the cockpit control panel.

The following equipment items are mounted on the CJB:

- Film speed control
- Camera drive motor and main power supply fuses
- A multipin test connector
- (12) light-emitting diode (LED) BIT indicators
- CJB test toggleswitch
- BIT initiate button
- Receptacle to accept inputs from the camera control box in the cockpit

There are two BIT LED's for each camera which indicate a film advance failure or a shutter or electronic component failure in the CJB. Two others indicate intervalometer pulse and film drive motor pulse. Two additional LED's are devoted to test functions.

All six PC boards and all five fuses may be removed without removing the CJB from the reconnaissance nose.

### Cockpit Controls

All inflight functions of the system are controlled from a panel mounted directly aft of the throttle control in the space vacated by the radar controls.

The panel, shown in Figure A-15, contains individual operating switches for the cameras, an intervalometer calibrated in seconds between frames, and switches to operate the go, no-go BIT circuits in each camera. In addition, the master switch contains a REMOTE position which permits the cameras to be maintained in a ready mode; the pilot can pulse them by means of a switch on the control stick. The panel also contains an override switch which permits operation of one camera, or all cameras, regardless of the position of the individual ON-OFF toggle switches. A standard

FRAMES REMAINING counter group provides the pilot a continuous reading of film remaining in each camera.

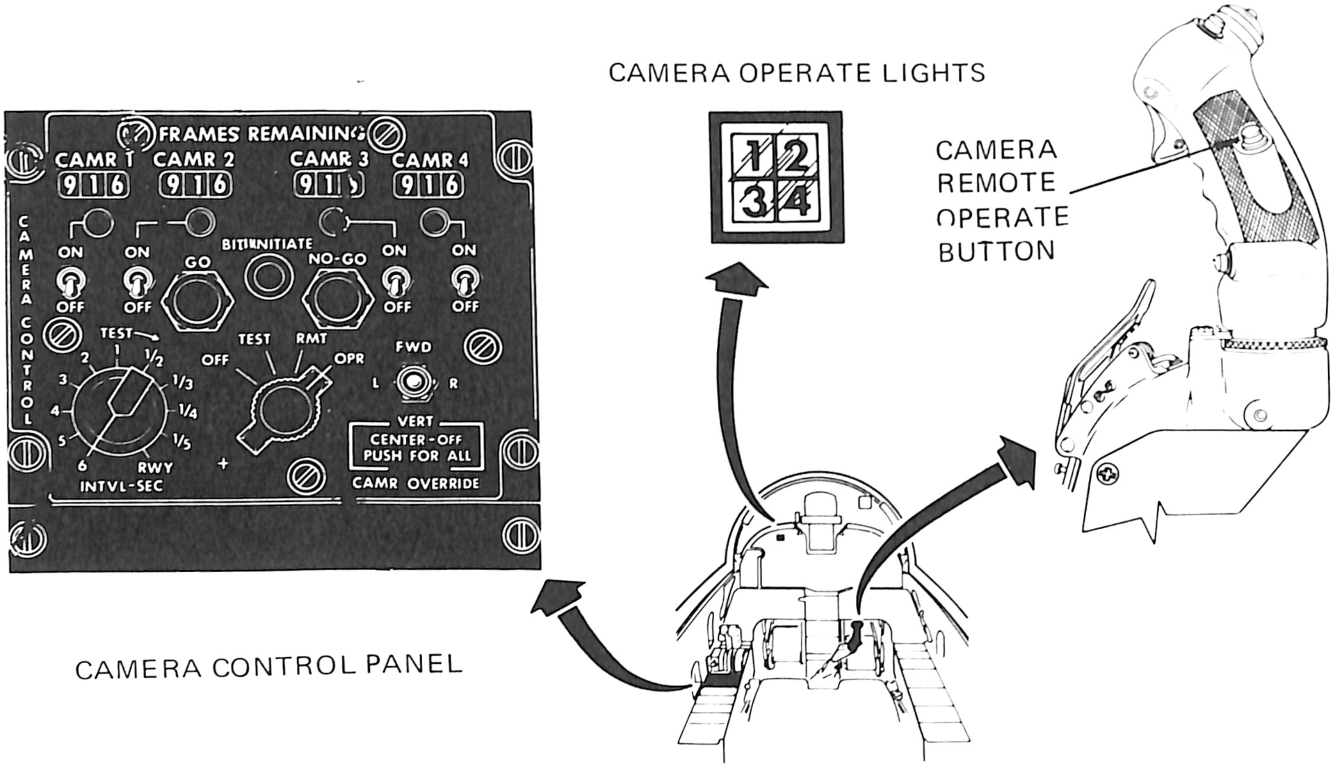

CAMERA OPERATE LIGHTS
1 2 3 4
CAMERA REMOTE OPERATE BUTTON
FRAMES REMAINING
CAMR 1
CAMR 2
CAMR 3
CAMR 4
916
916
91
916
CAMERA CONTROL
ON
OFF
ON
OFF
GO
BIT INITIATE
NO-GO
ON
OFF
ON
OFF
TEST
1
2
3
4
5
6
1/2
1/3
1/4
1/5
RWY
INTVL-SEC
OFF
TEST
RMT
OPR
FWD
L
R
VERT
CENTER-OFF
PUSH FOR ALL
CAMR OVERRIDE
CAMERA CONTROL PANEL

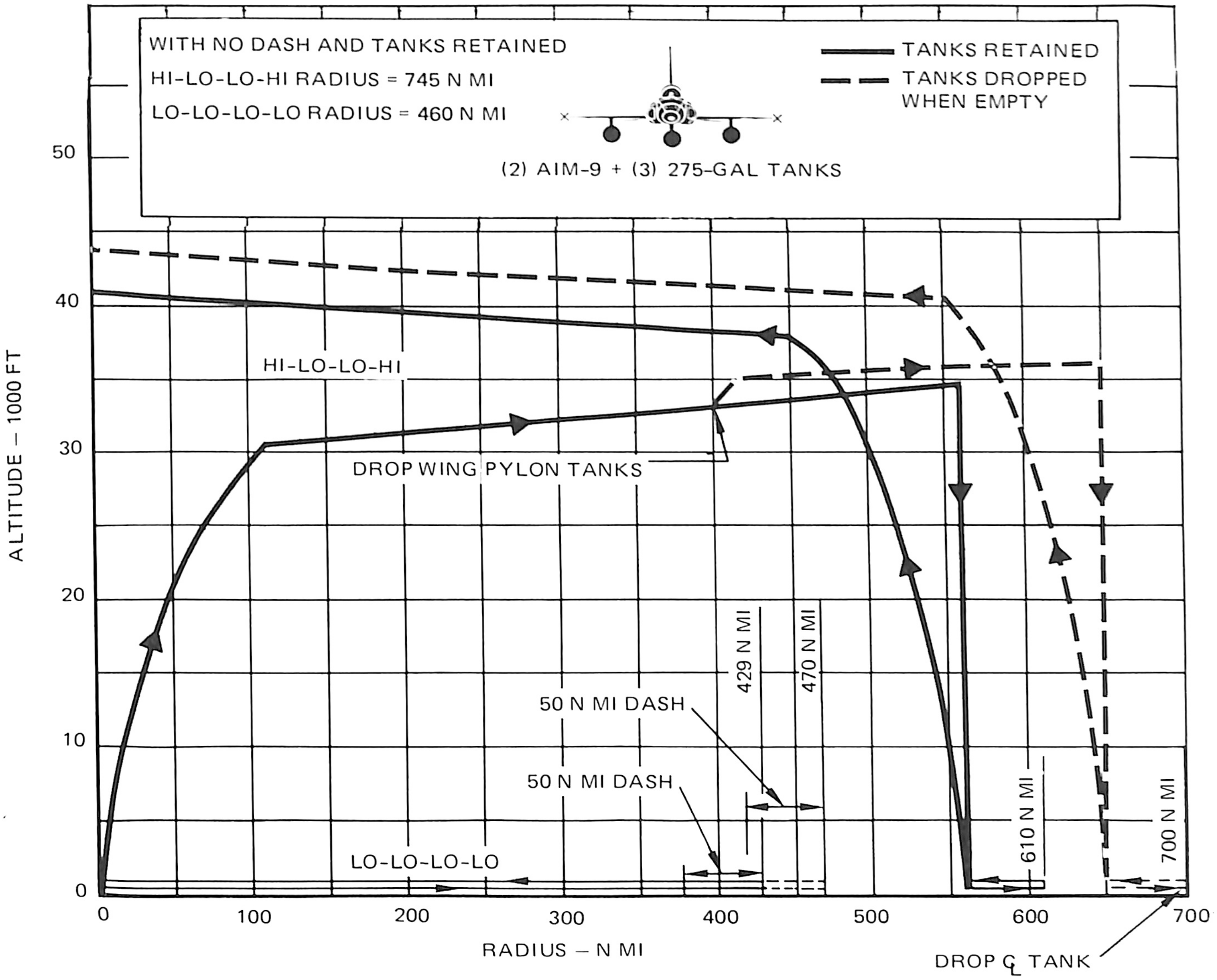
FIGURE A-15. CAMERA CONTROLS AND INDICATORS

### Performance Characteristics

The performance of the F-5E (Recon) is essentially the same as that of the basic F-5E tactical fighter. The F-5E (Recon) has a slightly higher supersonic drag level and the aircraft weight is about 35 pounds heavier, but for most performance items, the differences are slight. It has a maximum Mach number of 1.55 and a sea level rate of climb of 33,000 feet per minute with maximum power at a 50-percent internal fuel weight. Takeoff and landing distances are essentially the same as those of the basic F-5E airplane.

### Mission Performance

Mission profiles for LO-LO-LO-LO and HI-LO-LO-HI reconnaissance missions on a standard day using JP-4 fuel are shown in Figure A-16. The missions include a 50-nautical-mile dash at sea level at 0.75 Mach number both to and from the target. Profiles are shown for pylon tanks retained and for pylon tanks dropped when empty. The HI-LO-LO-HI mission radius is 700 nautical miles for tanks dropped when empty. Mission rules are tabulated on the figure.



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL FOR 10 MINUTES IDLE POWER PLUS FUEL FOR MAXIMUM POWER TAKEOFF AND SEA LEVEL ACCELERATION TO 300 KCAS PLUS FUEL FOR MILITARY POWER ACCELERATION TO CLIMB SPEED. NO DISTANCE CREDIT.
2 MILITARY POWER CLIMB
3 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE
4 DESCENT TO SEA LEVEL. NO FUEL, TIME OR DISTANCE CREDIT
5 DASH 50 N MI AT SEA LEVEL AT M = 0.75 TO AND FROM TARGET
6 TAKE PHOTOS. NO FUEL, TIME OR DISTANCE CREDIT
7 MILITARY POWER CLIMB
8 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE
9 DESCEND TO SEA LEVEL. NO FUEL, TIME OR DISTANCE CREDIT
10 LANDING RESERVES: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL
11 LO-LO-LO CRUISE IS AT SEA LEVEL.
12 PYLON TANKS ARE RETAINED OR DROPPED WHEN EMPTY AS NOTED. FULL AMMO, MISSILES AND PYLONS ARE RETAINED.

FIGURE A-16. F-5E RECONNAISSANCE MISSIONS

In addition to its primary role of photoreconnaissance, the F-5E (Recon) can be successfully employed for strike-reconnaissance, close air support, interdiction and intercept missions with only minor performance penalties compared to its F-5E counterpart. The Combat Air Patrol mission radius with recon nose and internal fuel only, for example, will be reduced by approximately 10 nautical miles.

Range of the F-5E (Recon) is essentially the same as for the basic F-5E airplane. With AIM-9 missiles, the F-5E (Recon) can fly more than 1735 nautical miles between bases, with tanks dropped when empty. This compares with 1755 nautical miles for the basic F-5E. The F-5E (Recon) and basic F-5E performance are compared in Table A-2.

### TABLE A-2. PERFORMANCE SUMMARY COMPARISON (LAUNCHER RAILS ONLY EXCEPT AS NOTED)

| | F-5E (RECON) | F-5E |
|---|---|---|
| TAKEOFF GROSS WEIGHT – (LB) | 15,326 | 15,292 |
| TAKEOFF GROUND RUN – (FT) | 1,810 | 1,800 |
| TAKEOFF SPEED – (KNOTS) | 144 | 144 |
| RATE OF CLIMB (SEA LEVEL) – (FPM) | 33,000 | 33,500 |
| MAXIMUM MACH NO. (36,089 FEET) | 1.55 | 1.6 |
| LANDING WEIGHT (LANDING FUEL RESERVES; AMMO EXPENDED) – (LB) | 11,226 | 11,192 |
| LANDING DISTANCE (WITH DRAG CHUTE) – (FT) | 2,210 | 2,200 |
| LANDING SPEED – (KNOTS) | 121 | 121 |
| FERRY RANGE (2) AIM-9 + (3) 275-GALLON TANKS, NO AMMO | | |
| TANKS RETAINED (N MI) | 1,540 | 1,555 |
| TANKS DROPPED (N MI) | 1,735 | 1,755 |

## Handling Characteristics

The F-5E (Recon) exhibits handling qualities similar to the basic F-5E fighter aircraft. The nose contour produces a slightly more positive zero-lift pitching moment but this has no significant effect on maneuverability or control.

## Airplane Weights

A summary defining the weight breakdown of the F-5E (Recon) with JP-4 fuel is presented in Table A-3.

### TABLE A-3. F-5E (RECON) WEIGHT SUMMARY – JP-4 FUEL

| AN-9103D GROUP | WEIGHT – LB |
|---|---|
| WING | 1,315 |
| TAIL | 306 |
| BODY | 2,263 |
| ALIGHTING GEAR | 765 |
| SURFACE CONTROLS | 427 |
| ENGINE SECTION | 174 |
| PROPULSION | 2,199 |
| INSTRUMENTS | 158 |
| HYDRAULICS | 152 |
| ELECTRICAL | 307 |
| ELECTRONICS | 172 |
| ARMAMENT | 223 |
| FURNISHINGS | 243 |
| AIR CONDITIONING AND ANTI-ICING | 177 |
| PHOTOGRAPHIC | 23 |
| AUXILIARY GEAR | 85 |
| WEIGHT EMPTY | 9,389 |
| PILOT AND EQUIPMENT | 240 |
| INTERNAL FUEL – USABLE | 4,400 |
| INTERNAL FUEL – UNUSABLE | 140 |
| ENGINE OIL AND OXYGEN | 31 |
| GUN INSTALLATION AND CAMERA | 541 |
| AMMUNITION AND LINKS | 394 |
| LAUNCHER RAILS | 98 |
| SURVIVAL KIT | 23 |
| NOSE CAMERA SYSTEM (CAMERAS, MAGAZINES, LENS, FILM, ETC.) | 69 |
| TAKEOFF WEIGHT (LAUNCHER RAILS) | 15,325 |

EXTERNAL TANKS AND FUEL

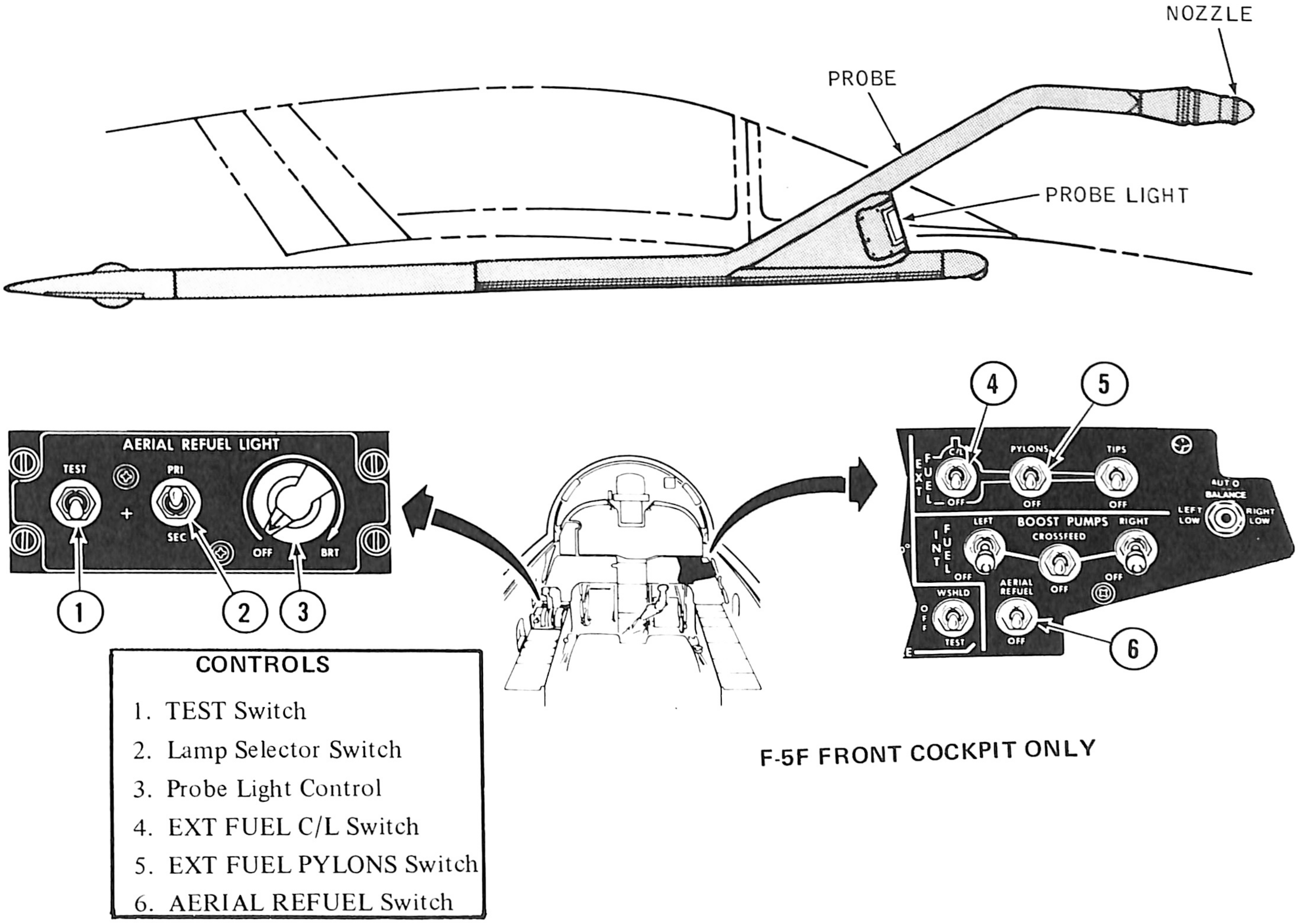
| | VOLUME, USABLE (U.S. GAL.) | TANKS, EMPTY (WT – LB) | FUEL, USABLE (WT – LB) |
|---|---|---|---|
| ℄ PYLON TANK | 150 | 147 | 975 |
| ℄ PYLON TANK | 275 | 213 | 1788 |
| INBD PYLON TANKS (2) | 300 | 306 | 1950 |
| INBD PYLON TANKS (2) | 550 | 432 | 3575 |
| WINGTIP TANKS (2) (GROWTH) | 96 | 243 | 624 |

FUEL WEIGHT COMPUTED AT 6.5 LB/GAL.

EMPTY TANK WEIGHTS INCLUDE RESIDUAL FUEL OF 13.0 LB FOR EACH PYLON TANK AND 6.5 LB FOR EACH TIP TANK.

## AIR REFUELING SYSTEM

The F-5E/F air refueling system* (Figure A-17) permits refueling of all internal fuel cells and external fuel tanks from KC-130 or KC-135 tanker aircraft by means of probe-and-drogue type refueling equipment. The probe assembly, consists of a probe tube, nozzle and probe light in a detachable unit which is mounted on the right side of the fuselage. The angle of attack vane is relocated to the left side of the fuselage. Fuel is routed from the probe to the single-point refueling system. A light in the probe forward fairing serves to illuminate the probe and tanker drogue for night refueling. Refer to Figure A-17 for location and function of the air refueling controls.


NOZZLE
PROBE
PROBE LIGHT
AERIAL REFUEL LIGHT
TEST
PRI
SEC
OFF
BRT
1
2
3
4
5
EXT FUEL
C/L
OFF
PYLONS
OFF
TIPS
OFF
AUTO BALANCE
LEFT LOW
RIGHT LOW
INT FUEL
LEFT
BOOST PUMPS
RIGHT
CROSSFEED
OFF
OFF
OFF
AERIAL REFUEL
OFF
WSHLD
OFF
TEST
6
F-5F FRONT COCKPIT ONLY

CONTROLS

1. TEST Switch
2. Lamp Selector Switch
3. Probe Light Control
4. EXT FUEL C/L Switch
5. EXT FUEL PYLONS Switch
6. AERIAL REFUEL Switch

FIGURE A-17. F-5E/F AIR REFUELING PROBE AND CONTROLS

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*The air refueling system for the F-5F is similar to the F-5E system except for the length of the external probe.

### System Operation

Air refueling with external tanks requires the following switch selections. When refueling at night, the probe light must be on. Before refueling with external tanks, the external fuel switches of the tanks installed must be turned on to open the fuel valve for each tank and the air refueling switch turned to AERIAL REFUEL to depressurize external tanks. These switch selections should be accomplished before hookup with the tanker drogue. After refueling is completed, external fuel switches and the air refueling switch must be turned off.

The fuel system diagram with air refueling is shown in Figure A-18.

The refueling times are shown below. These values assume 10% fuel on board at start and a KC 130F tanker:

Internal fuel only 3.7 minutes
Internal plus centerline 275-gallon tank 5.0 minutes
Internal plus (3) 275-gallon tanks 7.0 minutes.

Performance. Table A-4 presents comparisons of F-5E interdiction, close air support and ferry missions with and without air refueling. The missions are shown in detail on Figures A-21 through A-22. All refueling missions shown are flights of two F-5E's with a KC-130 tanker. The mission rules for the interdiction and ferry missions allow for return to base in the event that either F-5E aircraft is unable to complete the refueling process. Radius or range and distances flown to the completion of the refueling of the second aircraft are shown for the interdiction and ferry missions. Loiter times are shown for the close air support missions. Refueling for the close air support mission of 150 nautical mile radius occurs at 50 nautical miles from base on the outbound leg. In this case an unsuccessful refueling by one aircraft need not preclude either aircraft from completing the mission, although loiter times will be considerably reduced for the aircraft not receiving fuel. Mission rules are presented with the figures. All performance is for a standard atmosphere and JP-4 fuel.

Weights. Provisions for aerial refueling add 22 pounds to the basic F-5E weight. The probe weighs an additional 73 pounds resulting in a total installed refueling weight of 95 pounds. For the F-5F, the provision for weight is 22 pounds and the probe weighs an additional 89 pounds resulting in a total installed weight of 111 pounds.

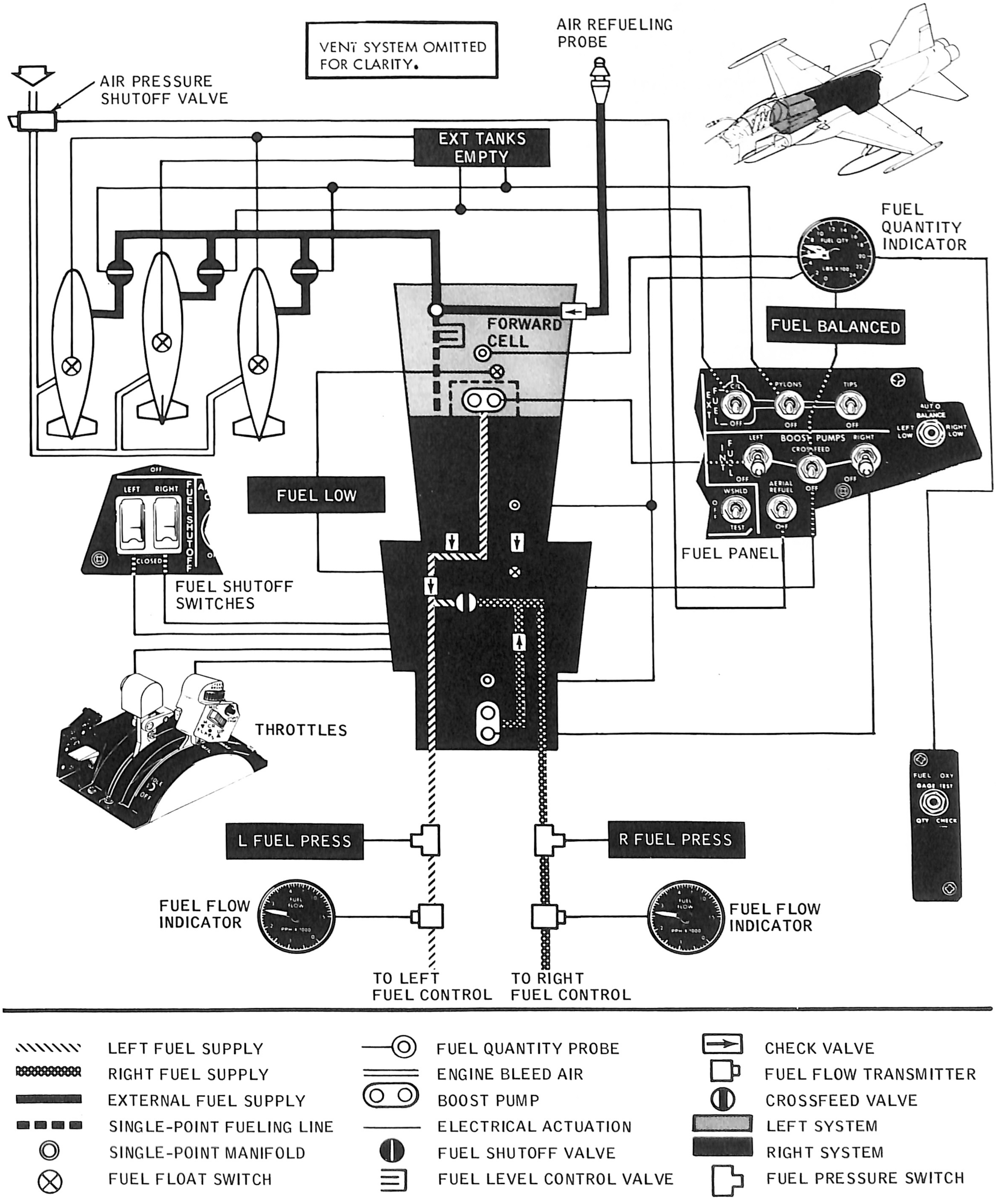

VENT SYSTEM OMITTED FOR CLARITY.
AIR REFUELING PROBE
AIR PRESSURE SHUTOFF VALVE
EXT TANKS EMPTY
FUEL QUANTITY INDICATOR
FUEL BALANCED
FORWARD CELL
FUEL LOW
FUEL SHUTOFF SWITCHES
LEFT
RIGHT
OFF
CLOSED
FUEL SHUTOFF
FUEL PANEL
EXT FUEL
C/L
PYLONS
TIPS
OFF
BOOST PUMPS
CROSSFEED
INT FUEL
AUTO BALANCE
LEFT LOW
RIGHT LOW
WSHLD
TEST
AERIAL REFUEL
THROTTLES
L FUEL PRESS
R FUEL PRESS
FUEL FLOW INDICATOR
FUEL FLOW INDICATOR
TO LEFT FUEL CONTROL
TO RIGHT FUEL CONTROL
FUEL QTY GAGE TEST
QTY CHECK
LEFT FUEL SUPPLY
RIGHT FUEL SUPPLY
EXTERNAL FUEL SUPPLY
SINGLE-POINT FUELING LINE
SINGLE-POINT MANIFOLD
FUEL FLOAT SWITCH
FUEL QUANTITY PROBE
ENGINE BLEED AIR
BOOST PUMP
ELECTRICAL ACTUATION
FUEL SHUTOFF VALVE
FUEL LEVEL CONTROL VALVE
CHECK VALVE
FUEL FLOW TRANSMITTER
CROSSFEED VALVE
LEFT SYSTEM
RIGHT SYSTEM
FUEL PRESSURE SWITCH

FIGURE A-18. FUEL SYSTEM WITH AIR REFUELING

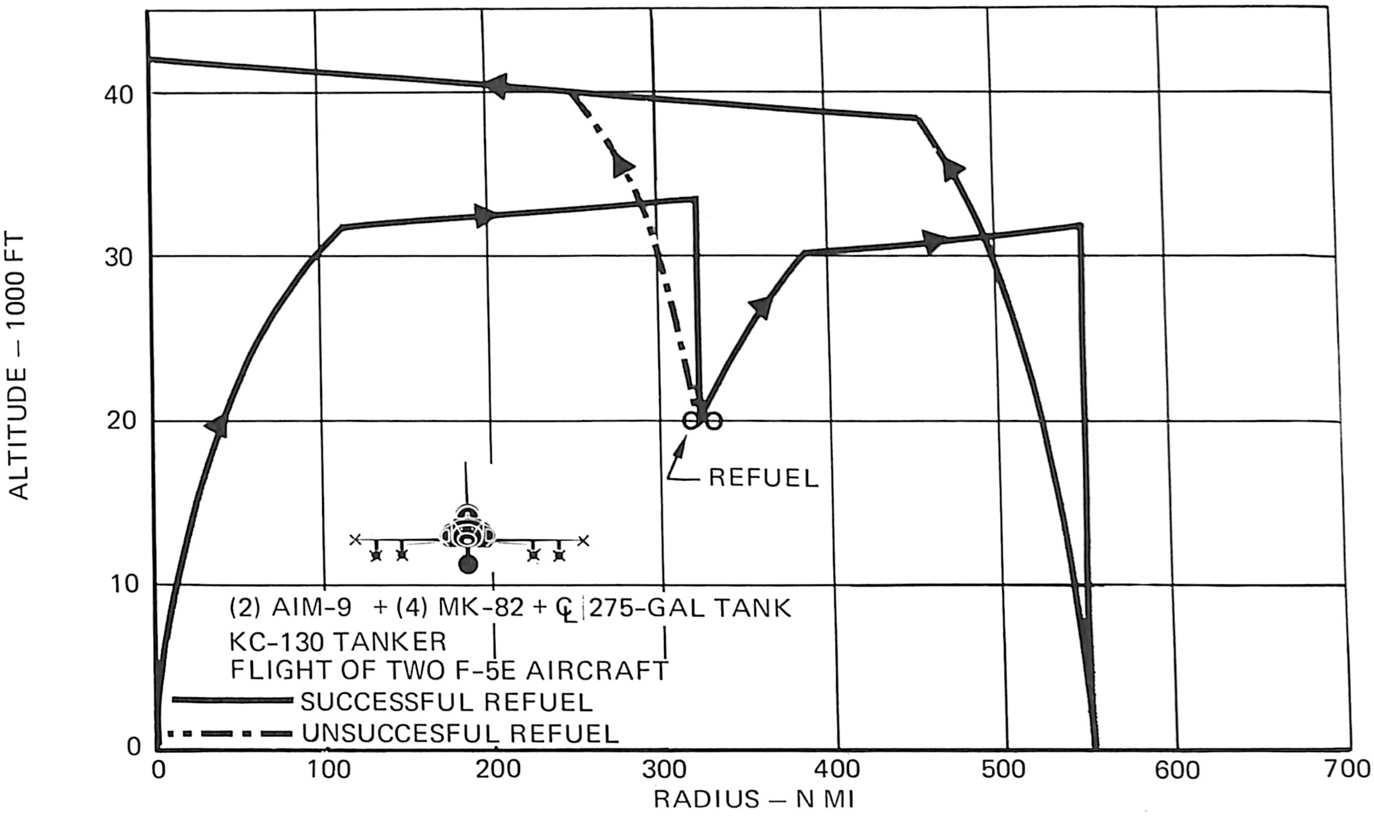
## TABLE A-4. F-5E MISSION PERFORMANCE COMPARISON (REFUELING FROM KC-130 AT 20,000 FEET, 220 KCAS) JP-4 FUEL, STANDARD DAY

| | DISTANCE TO END OF REFUELING (N MI) | TOTAL RADIUS WITH ONE REFUELING (N MI) | NO REFUEL RADIUS (N MI) |
|---|---|---|---|
| INTERDICTION RADIUS, HI-LO-HI | | | |
| (2) AIM-9 + 275-GALLON ℄ TANK + (4) MK-82 | 325 | 550 | 340 |
| (2) AIM-9 + 275-GALLON ℄ TANK + (4) BLU-27/B | 270 | 500 | 295 |

| | LOITER TIME WITH ONE REFUELING (MINUTES) | LOITER TIME WITH NO REFUELING (MINUTES) |
|---|---|---|
| CLOSE AIR SUPPORT | | |
| (RADIUS = 150 N MI, REFUEL 50 N MI FROM BASE) | | |
| (2) AIM-9 + 275-GALLON ℄ TANK + (4) MK-82, 8 MIN COMBAT | 48 | 34 |
| (2) AIM-9 + 275-GALLON ℄ TANK + (4) BLU-27/B, 8 MIN COMBAT | 39 | 25 |

| | DISTANCE TO END OF REFUELING (N MI) | TOTAL RANGE WITH ONE REFUELING (N MI) | NO REFUEL RANGE (N MI) |
|---|---|---|---|
| FERRY RANGE | | | |
| RAILS + 275-GALLON ℄ TANK | | | |
| TANK RETAINED | 535 | 1,875 | 1,315 |
| TANK DROPPED | 535 | 1,945 | 1,395 |
| (2) AIM-9 + (3) 275-GALLON TANKS | | | |
| TANKS RETAINED | 650 | 2,180 | 1,555 |
| TANKS DROPPED | 650 | 2,390 | 1,755 |

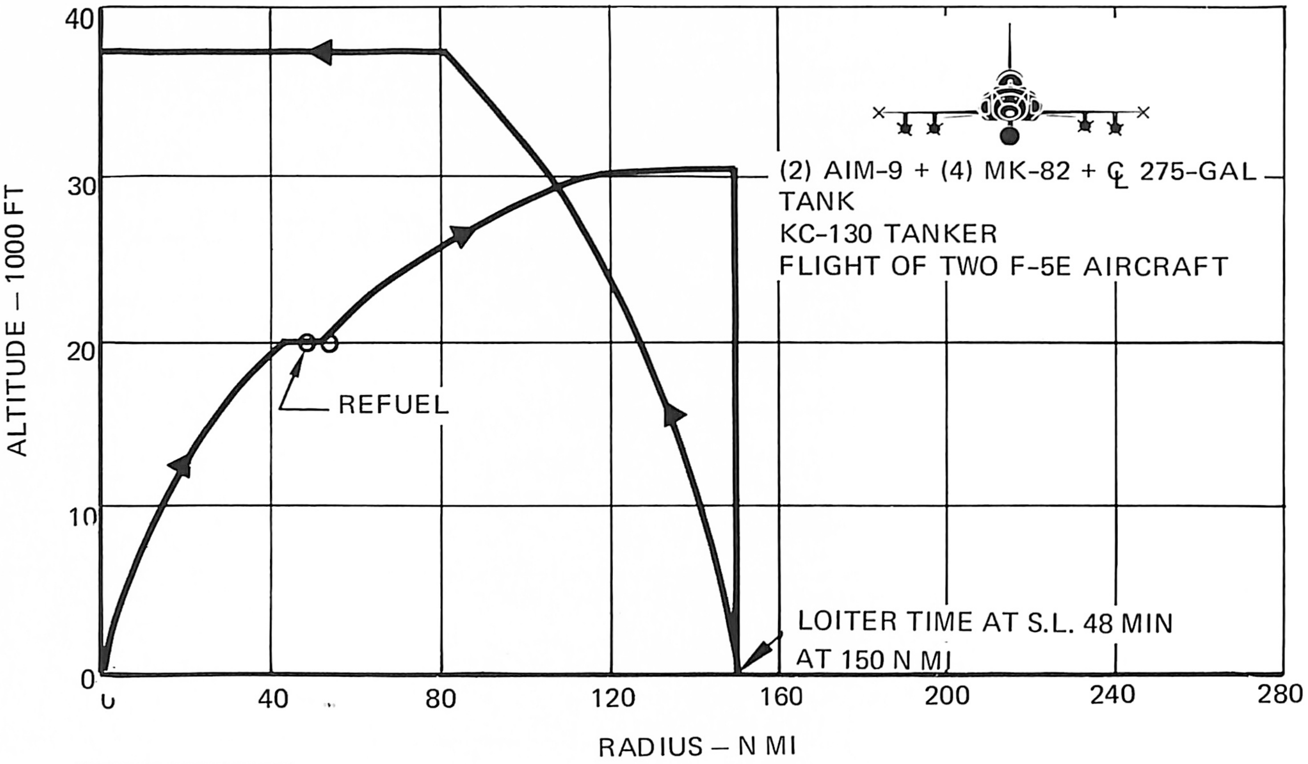
SEE FIGURES A-19 THROUGH A-22 FOR MISSION RULES.



MISSION RULES

1 TAKEOFF ALLOWANCE: 10 MINUTES IDLE POWER FUEL FLOW PLUS FUEL TO TAKEOFF AND ACCELERATE TO MILITARY POWER CLIMB SPEED.
2 MILITARY POWER CLIMB TO BEST CRUISE ALTITUDE.
3 CRUISE/CLIMB AT OPTIMUM SPEED AND AT OPTIMUM ALTITUDE TO REFUEL POINT.
4 REFUEL AT 20,000 FEET ALTITUDE AND 220 KCAS.
5 FIVE-MINUTE ALLOWANCE FOR RENDEZVOUS, NO DISTANCE CREDIT.
6 UNSUCCESSFUL REFUEL: 10 MINUTES ADDITIONAL ALLOWANCE INCLUDING 5 MINUTES FOR AIRCRAFT TO REFUEL AND 5 MINUTES FOR SECOND AIRCRAFT TO DETERMINE THAT A HOOKUP CANNOT BE ACCOMPLISHED. DROP BOMBS AND RETURN TO BASE AT OPTIMUM CRUISE ALTITUDE PLUS LANDING RESERVES OF 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.
7 SUCCESSFUL REFUELS: FIVE MINUTES MAXIMUM ENDURANCE ALLOWANCE AT ALTITUDE WHILE SECOND AIRCRAFT REFUELS.
8 MILITARY CLIMB TO BEST CRUISE ALTITUDE.
9 CRUISE TO TARGET.
10 DESCEND TO SEA LEVEL: NO TIME, FUEL AND DISTANCE CREDIT.
11 COMBAT ALLOWANCE: FIVE MINUTES MILITARY POWER FUEL FLOW ALLOWANCE AT .70 MACH NUMBER AT SEA LEVEL.
12 DROP BOMBS AND FIRE AMMUNITION.
13 MILITARY POWER CLIMB TO BEST CRUISE ALTITUDE.
14 CRUISE/CLIMB AT OPTIMUM SPEED AND AT OPTIMUM ALTITUDE FOR RETURN TO BASE.
15 DESCEND TO SEA LEVEL: NO TIME, FUEL AND DISTANCE CREDIT.
16 LANDING RESERVE: FUEL FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.
17 TANKS, PYLON AND MISSILES ARE RETAINED.

FIGURE A-19. F-5E INTERDICTION HI-LO-HI WITH AIR REFUELING



MISSION RULES

1 TAKEOFF ALLOWANCE: 10 MINUTES IDLE POWER FUEL FLOW PLUS FUEL TO TAKEOFF AND ACCELERATE TO MILITARY POWER CLIMB SPEED.

2 MILITARY POWER CLIMB TO 20,000 FEET ALTITUDE.

3 CRUISE AT OPTIMUM SPEED AND AT 20,000 FEET.

4 REFUEL AT 20,000 FEET ALTITUDE AND 220 KCAS. REFUEL POINT SPECIFIED.

5 FIVE-MINUTE ALLOWANCE FOR RENDEZVOUS, NO DISTANCE CREDIT.

6 UNSUCCESSFUL REFUEL: DROP BOMBS AND RETURN TO BASE AT OPTIMUM CRUISE ALTITUDE PLUS LANDING RESERVES OF 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL, OR CONTINUE MISSION WITH REDUCED LOITER TIME.

7 SUCCESSFUL REFUEL: FIVE MINUTES MAXIMUM ENDURANCE ALLOWANCE AT ALTITUDE WHILE SECOND AIRCRAFT REFUELS.

8 MILITARY POWER CLIMB TO BEST CRUISE ALTITUDE.

9 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION.

10 DESCENT: TO SEA LEVEL, NO FUEL, TIME OR DISTANCE CREDIT.

11 LOITER: MAXIMUM ENDURANCE AT SEA LEVEL. MAX RADIUS POINT SPECIFIED.

12 COMBAT: MILITARY POWER COMBAT AT SEA LEVEL AT 0.7 MACH NUMBER IN ACCORDANCE WITH FOLLOWING TABLE WHICH INCLUDES 4 MINUTES FOR GUN FIRING PLUS TIME FOR AIR-TO-GROUND ORDNANCE DELIVERY.

| NO. BOMBS | COMBAT TIME (MINUTES) |
|---|---|
| 1 OR 2 | 6 |
| 3 OR 4 | 8 |
| 5 OR 6 | 10 |

13 MILITARY POWER CLIMB TO BEST CRUISE ALTITUDE.

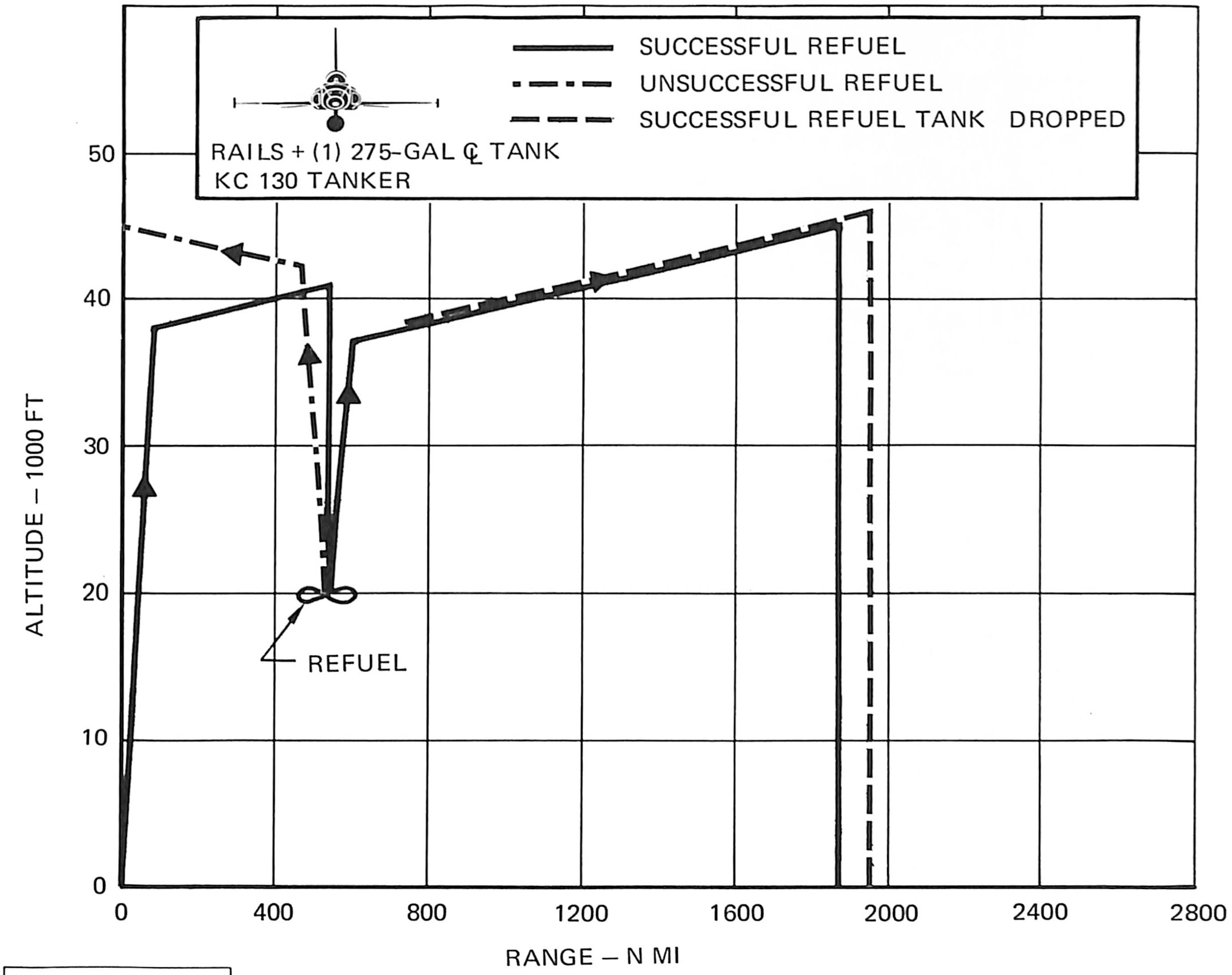
14 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE.

15 DESCENT: TO SEA LEVEL, NO FUEL, TIME OR DISTANCE CREDIT.

16 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.

17 TANKS, PYLONS AND MISSILES ARE RETAINED.

FIGURE A-20. F-5E CLOSE AIR SUPPORT WITH AIR REFUELING



MISSION RULES

1 TAKEOFF ALLOWANCE: 10 MINUTES IDLE POWER FUEL FLOW PLUS FUEL TO TAKEOFF AND ACCELERATE TO MILITARY POWER CLIMB SPEED.

2 MILITARY POWER CLIMB TO BEST CRUISE ALTITUDE.

3 CRUISE/CLIMB AT OPTIMUM SPEED AND AT OPTIMUM ALTITUDE TO REFUEL POINT.

4 REFUEL AT 20,000 FEET ALTITUDE AND 220 KCAS.

5 FIVE MINUTE ALLOWANCE FOR RENDEZVOUS, NO DISTANCE CREDIT.

6 UNSUCCESSFUL REFUEL: 10 MINUTES ADDITIONAL ALLOWANCE INCLUDING 5 MINUTES FOR AIRCRAFT TO REFUEL AND 5 MINUTES FOR SECOND AIRCRAFT TO DETERMINE THAT A HOOK-UP CANNOT BE ACCOMPLISHED. RETURN TO BASE WITH TANKS AT OPTIMUM CRUISE ALTITUDE PLUS LANDING RESERVES OF 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.

7 SUCCESSFUL REFUELS: FIVE MINUTES MAXIMUM ENDURANCE ALLOWANCE AT ALTITUDE WHILE SECOND AIRCRAFT REFUELS.

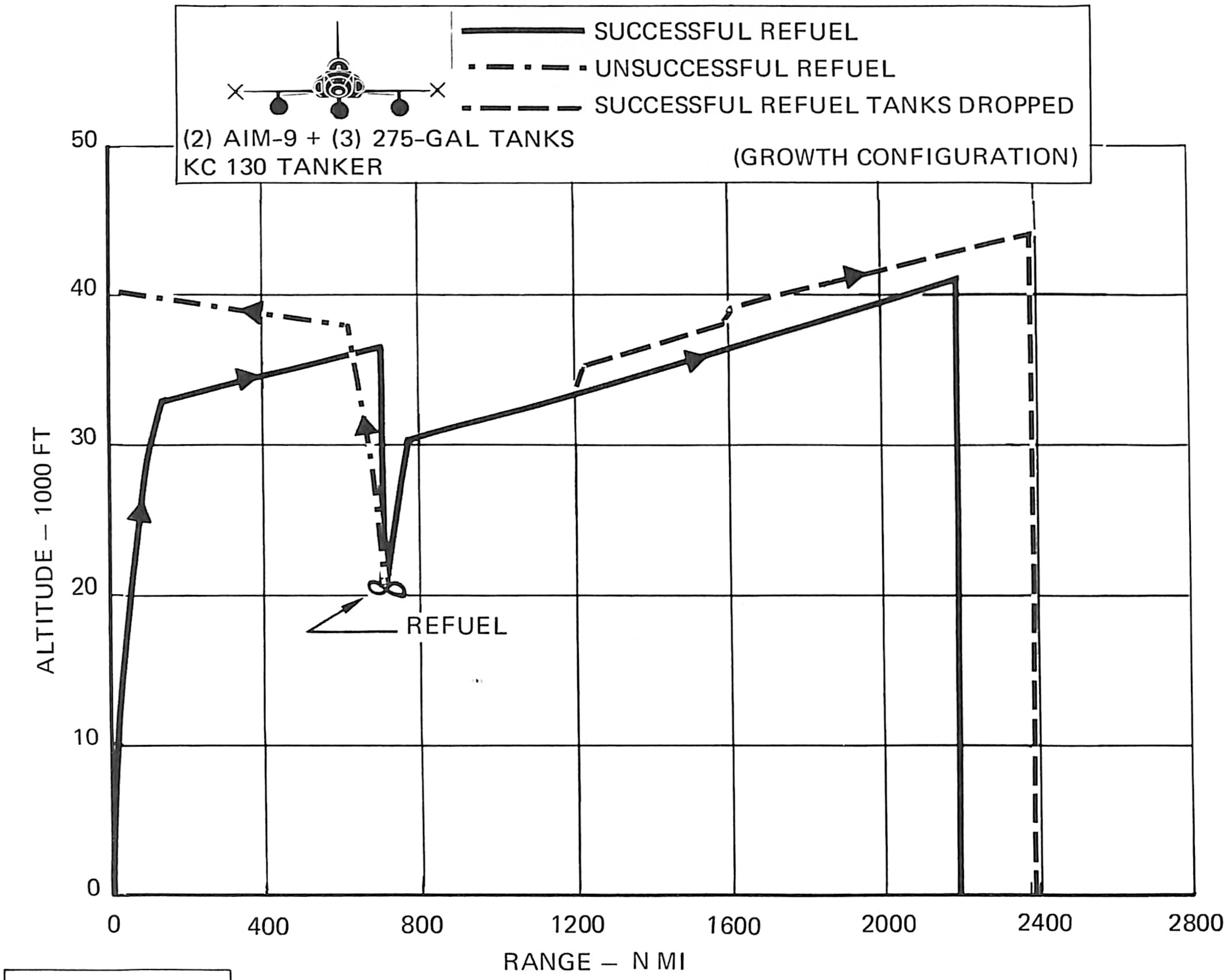
8 MILITARY POWER CLIMB TO BEST CRUISE ALTITUDE.

9 CRUISE/CLIMB AT OPTIMUM SPEED AND AT OPTIMUM ALTITUDE.

10 IF TANK IS DROPPED, IT IS DROPPED WHEN EMPTY AFTER REFUELING.

11 LANDING RESERVE: FUEL FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.

FIGURE A-21. F-5E FERRY MISSION WITH AIR REFUELING – (1) 275-GAL TANK



MISSION RULES

1 TAKEOFF ALLOWANCE: 10 MINUTES IDLE POWER FUEL FLOW PLUS FUEL TO TAKEOFF AND ACCELERATE TO MILITARY POWER CLIMB SPEED.

2 MILITARY POWER CLIMB TO BEST CRUISE ALTITUDE.

3 CRUISE/CLIMB AT OPTIMUM SPEED AND AT OPTIMUM ALTITUDE TO REFUEL POINT.

4 REFUEL AT 20,000 FEET ALTITUDE AND 220 KCAS.

5 FIVE MINUTE ALLOWANCE FOR RENDEZVOUS, NO DISTANCE CREDIT.

6 UNSUCCESSFUL REFUEL: 10 MINUTES ADDITIONAL ALLOWANCE INCLUDING 5 MINUTES FOR AIRCRAFT TO REFUEL AND 5 MINUTES FOR SECOND AIRCRAFT TO DETERMINE THAT A HOOK-UP CANNOT BE ACCOMPLISHED. RETURN TO BASE WITH TANKS AT OPTIMUM CRUISE ALTITUDE PLUS LANDING RESERVES OF 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.

7 SUCCESSFUL REFUELS: FIVE MINUTES MAXIMUM ENDURANCE ALLOWANCE AT ALTITUDE WHILE SECOND AIRCRAFT REFUELS.

8 MILITARY POWER CLIMB TO BEST CRUISE ALTITUDE.

9 CRUISE/CLIMB AT OPTIMUM SPEED AND AT OPTIMUM ALTITUDE.

10 IF TANKS ARE DROPPED, THEY ARE DROPPED WHEN EMPTY AFTER REFUELING.

11 LANDING RESERVE: FUEL FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL.

FIGURE A-22. F-5E FERRY MISSION WITH AIR REFUELING – (3) 275-GAL TANKS

## EXTERNAL TANKS

The F-5E/F aircraft are delivered with a single 275-gallon centerline tank. Two 275-gallon wing tanks and the kits to convert the tanks for carriage on either the centerline or wing pylons may be obtained as an option. The 275-gallon centerline and inboard wing pylon tanks are interchangeable by installation of the proper vertical fin (short fin on the centerline tank and full depth fin on wing pylon tanks), rearrangement of the suspension lugs (30-inch spacing for centerline, 14-inch spacing for wing pylons), addition of sway brace pad shims on the wing pylon tanks, and rearrangement of the fuel ports and seal cover plates. Aircraft performance with either one, two or three 275-gallon pylon tanks is presented in Section 2.

In addition, 150-gallon pylon tanks and associated conversion kits may also be obtained as an option for carriage on the centerline and/or wing pylons. While the range improvement of the 150-gallon tanks is only about 60 percent of the improvement with 275-gallon tanks, the 150-gallon tank option may be of interest to countries now flying F-5A/B airplanes who may have a supply of these tanks in inventory or countries whose mission requirements do not necessitate the larger tanks.

Provisions exist in the 275-gallon and 150-gallon tank designs that extend their capabilities for use with the air refueling option. Kits are available to modify all pylon tanks for this purpose.

## JETTISONABLE PYLONS

The F-5E/F aircraft have complete provisions for pylon jettison capability. In order to make the pylons jettisonable, it is necessary to procure and install jettison system kits in each pylon.

The jettison system consists of a dual bridgewire initiator, confined detonating fuze (CDF) assemblies, thruster assembly, J-hook assembly, explosive bolts or studs, and miscellaneous hardware. The centerline pylon jettison system is shown in Figure A-23. The inboard and outboard pylon jettison systems have similar major components but differ slightly due to length and routing of the CDF assemblies, location of the initiators, and the number of explosive studs required to attach the pylons to the wing, as shown in Figure A-24.

The initiator is connected to the explosive attachments by redundant CDF's and is located in the aft section of the wing pylons and in the forward section of the centerline pylon. The CDF's are routed through the pylon interior to connect with the pylon explosive attachments. An access door is provided for installation and removal of the initiator. For flight line safety, a jettison circuit safety pin is inserted in the pylon to disable the jettison circuit.

When the initiator is fired, the CDF produces a detonating shockwave to the explosive attachments which detonate, causing pylon separation. At separation, a J-hook, located at the aft end of the pylon, causes the leading edge of the pylon to rotate down and aft to assure airplane clearance. Pull away connectors are used for electrical, fuel and air lines.

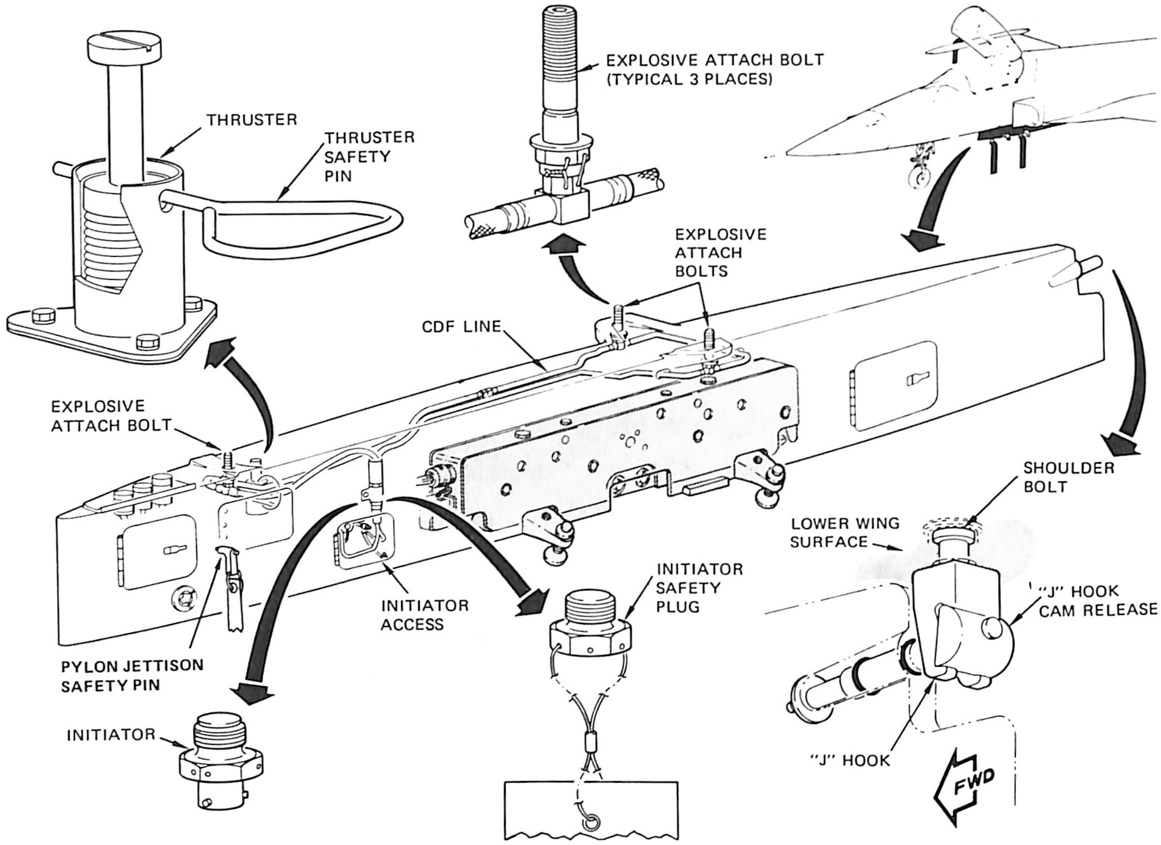

THRUSTER
THRUSTER SAFETY PIN
EXPLOSIVE ATTACH BOLT (TYPICAL 3 PLACES)
EXPLOSIVE ATTACH BOLTS
CDF LINE
EXPLOSIVE ATTACH BOLT
SHOULDER BOLT
LOWER WING SURFACE
INITIATOR SAFETY PLUG
"J" HOOK CAM RELEASE
INITIATOR ACCESS
PYLON JETTISON SAFETY PIN
INITIATOR
"J" HOOK
FWD

FIGURE A-23. CENTERLINE PYLON JETTISON SYSTEM

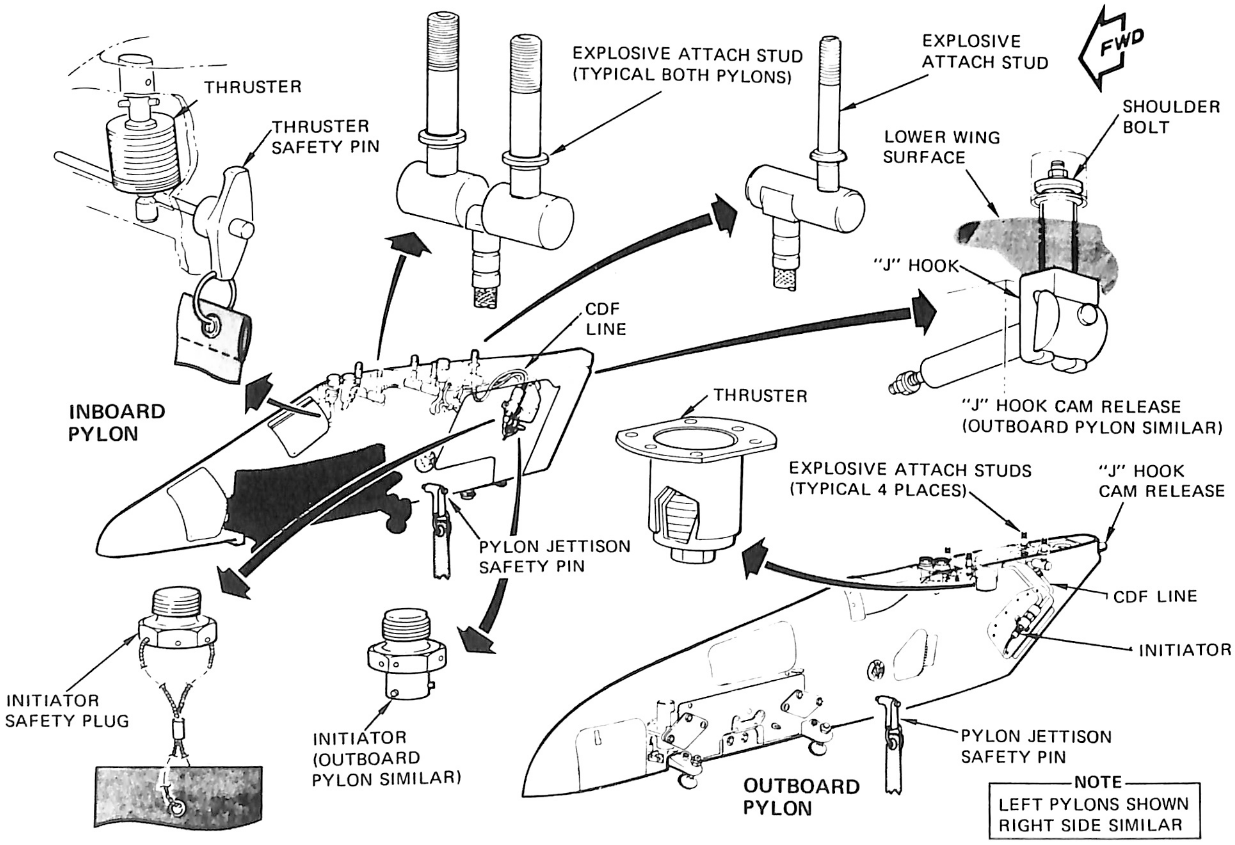

THRUSTER
THRUSTER SAFETY PIN
EXPLOSIVE ATTACH STUD (TYPICAL BOTH PYLONS)
EXPLOSIVE ATTACH STUD
FWD
SHOULDER BOLT
LOWER WING SURFACE
"J" HOOK
CDF LINE
INBOARD PYLON
THRUSTER
"J" HOOK CAM RELEASE (OUTBOARD PYLON SIMILAR)
EXPLOSIVE ATTACH STUDS (TYPICAL 4 PLACES)
"J" HOOK CAM RELEASE
PYLON JETTISON SAFETY PIN
CDF LINE
INITIATOR
INITIATOR SAFETY PLUG
INITIATOR (OUTBOARD PYLON SIMILAR)
PYLON JETTISON SAFETY PIN
OUTBOARD PYLON
NOTE
LEFT PYLONS SHOWN
RIGHT SIDE SIMILAR

FIGURE A-24. INBOARD AND OUTBOARD WING PYLON JETTISON SYSTEMS

## MULTIPLE EJECTOR RACK

A MER-5E Multiple Ejector Rack is available for use on the centerline pylon on the F-5E/F aircraft. The MER-5E accommodates five MK-82 bombs, either low-drag or high-drag (Snakeye) type. The low drag bombs may be single or ripple released. The Snakeye bombs are always ripple released.

The MER-5E (Figure A-25) is composed of a hollow hexagonal longitudinal beam assembly to which are affixed two tandem clusters of ejector racks, three (3) racks forward and two (2) racks aft. The forward cluster is arranged with two shoulder positions and one lower centerline position. The aft cluster has two shoulder positions only. The MER-5E has 30-inch suspension lugs and sway brace pads for mounting on the aircraft centerline pylon.

The five individual bomb racks have 14-inch lug spacing. Each rack is equipped with bomb sway braces, release mechanism, ejectors, bomb sensing switch, and a safety lever. The safety lever is provided at the aft end of each ejector rack to block the toggle linkage mechanism against release by inadvertent firing of the ejector during

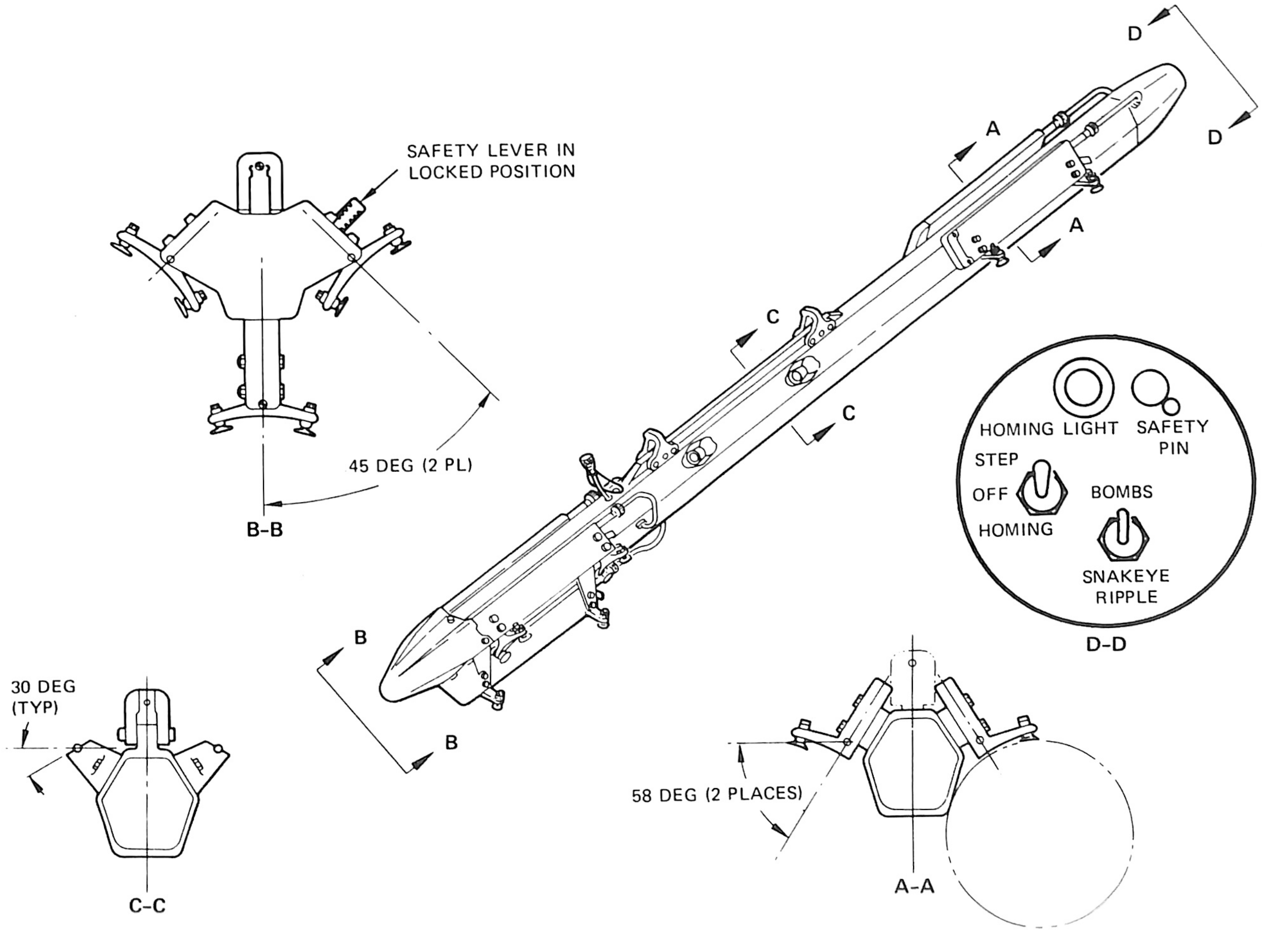

D
D
A
A
SAFETY LEVER IN
LOCKED POSITION
C
C
45 DEG (2 PL)
B-B
HOMING LIGHT
SAFETY
PIN
STEP
OFF
HOMING
BOMBS
SNAKEYE
RIPPLE
D-D
B
B
30 DEG
(TYP)
C-C
58 DEG (2 PLACES)
A-A

FIGURE A-25. MER-5E MULTIPLE EJECTOR RACK ground operation. This eliminates the requirement for separate safety pins. The safety lever cannot be placed in the locked position until the hooks are closed and latched and the breech is in the locked position. The safety also acts as a flag to indicate the safe or armed condition of the rack.

A panel in the MER-5E tail cone contains the release mode switch, a homing switch, a homing test light and an electrical safety switch controlled by insertion of a safety pin. The electrical control system provides automatic circuits to: (1) position the release firing signal to the first loaded station in the firing sequence (homing); (2) bypass empty stations so that each firing pulse releases a store; and (3) stop seeking when all stations are unloaded. The release mode switch has a BOMBS position and a SNAKEYE RIPPLE position. Selection is made in accordance with the type of bombs loaded on the MER.

For low drag bombs, the MER selector is positioned to BOMBS. For Snakeye bombs, the MER selector is positioned to SNAKEYE RIPPLE which sets an internal MER intervalometer for bomb release at 275-millisecond intervals. For low drag bombs, the armament controls in the cockpit are set up for either single or ripple bomb release. For single release, the EXTERNAL STORES selector in the cockpit is placed in the BOMB position and the MISSILE/BOMB/ROCKET button on the control stick is depressed one time for each bomb to be released. For ripple release, the EXTERNAL STORES selector is placed in the RIPL position, the INTERVAL selector positioned to the desired interval and the MISSILE/BOMB/ROCKET button depressed. Ripple release of the bombs is then accomplished by pulses from the aircraft intervalometer.

For ripple release of the Snakeye bombs, the EXTERNAL STORES SELECTOR is placed in the BOMB position and the MISSILE/BOMB/ROCKET button depressed for at least 1.5 seconds to allow the MER intervalometer to ripple all bombs at 275-milliseconds intervals.

## IMPROVED NORTHROP ESCAPE SYSTEM

The improved Northrop escape system differs from the basic Northrop F-5E/F Escape System described in Section 4 in two areas. It has a seat stabilization and retardation chute and a new fast opening personnel parachute. The F-5E/F improved escape system is fully automatic and provides survival capability at aircraft speeds from 50 knots at ground level to 550 knots at altitude.

The seat equipment includes all of the equipment of the basic seat plus a drogue-gun-deployed seat stabilization drogue chute. The system utilizes all of the personal equipment/ejection seat interface items of the basic system except for the personnel parachute. Photographs of the seat are shown in Figure A-26.

Seat Stabilization and Retardation Chute. A seat stabilization and retardation parachute has been added to the escape system in order to reduce the possibility of entanglement during main personnel chute deployment by controlling seat attitude and by rapidly separating the seat from the man at the time of lap belt separation. It makes higher velocity, low altitude escapes possible through more rapid deceleration to a point below the critical main chute opening velocity, thus allowing a reduction of the

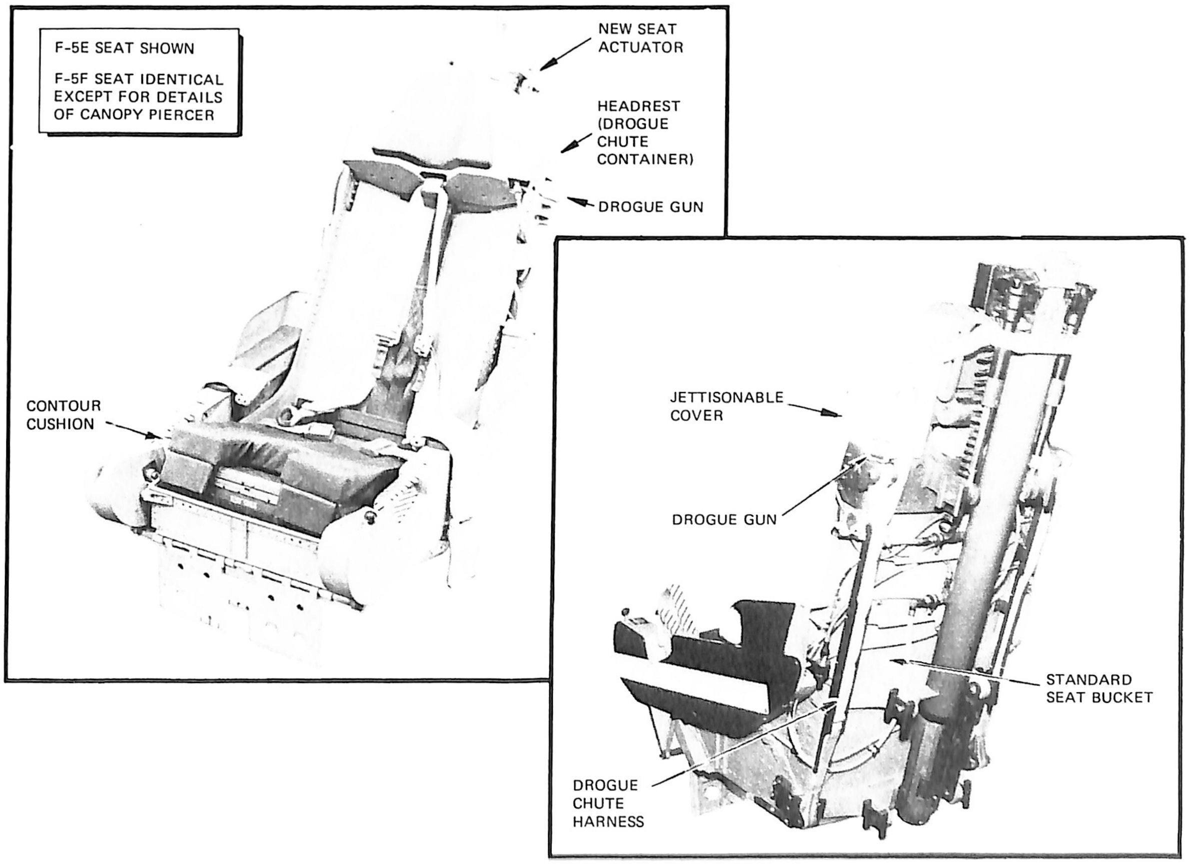

F-5E SEAT SHOWN
F-5F SEAT IDENTICAL EXCEPT FOR DETAILS OF CANOPY PIERCER
NEW SEAT ACTUATOR
HEADREST (DROGUE CHUTE CONTAINER)
DROGUE GUN
CONTOUR CUSHION
JETTISONABLE COVER
DROGUE GUN
STANDARD SEAT BUCKET
DROGUE CHUTE HARNESS

FIGURE A-26. F-5E/F IMPROVED EJECTION SEAT time to main chute deployment. This feature also results in larger envelopes for safe low level ejections at high sink rates and in inverted flight. The system is stored in the seat behind the head rest.

The seat chute system consists of a drogue gun, deployment sleeve, restrictor release lanyard, and the canopy and harness.

> The drogue gun is activated by pressure from the M-26 escape system initiator. This pressure triggers a 0.019-second pyrotechnic delay in the gun cartridge which times the gun action to aircraft/seat separation. At separation, the cartridge fires, launching a 2-pound projectile horizontally 45° aft at 290 ft/sec.
>
> The deployment sleeve serves to protect the chute, and to align it for proper inflation as it is deployed. The sleeve consists of a pocket to contain the chute, a skirt with provisions for orderly storage of suspension lines and a restrictor band. An incremental bridle is attached to the apex of the sleeve. This bridle is fitted to the drogue gun at final installation, and serves to attenuate the shock of the gun's deployment projectile as it transfers energy from the projectile to the parachute pack sleeve.
>
> The restrictor release lanyard is used to lock the restrictor band on the sleeve in the closed position and is attached to the seat structure. The restrictor band circles the folded chute just below the vent lines and prevents the chute from slumping to the bottom of the sleeve during peak extraction loads. When the chute pack is up to speed, the lanyard is pulled, freeing the chute to separate from the sleeve.
>
> The canopy is a 78-inch hemisflo ribbon type parachute. It has a variable porosity 78-inch riser, 82-inch suspension lines, and a blow-out vent cover to assure successful high and low velocity inflation. The seat harness is secured to the seat through two upper and two lower attach points and is attached to the parachute riser through a convenient disconnect for ease of parachute pack installation and maintenance.

Fast Opening Personnel Parachute. The second subsystem of the improved Northrop escape system is the Stencel Aero Engineering Company BA-25 personnel parachute. The design eliminates the need for the zero delay lanyard and provides a more positive means of opening the chute using a fail safe spreader gun.

Ejection Sequence. The seat ejection sequence is shown in Figure A-27. The typical time values shown on the figure assume an ejection velocity of 150 knots.

F-5F System. The F-5F escape system is identical to the F-5E system except for details of the seat canopy piercer design. The F-5F seats operate independently and are not sequenced on ejection. The seat chute drogue guns fire at a 45° angle which precludes the projectile from the front seat hitting the pilot in the rear seat in the remote chance of simultaneous ejection.

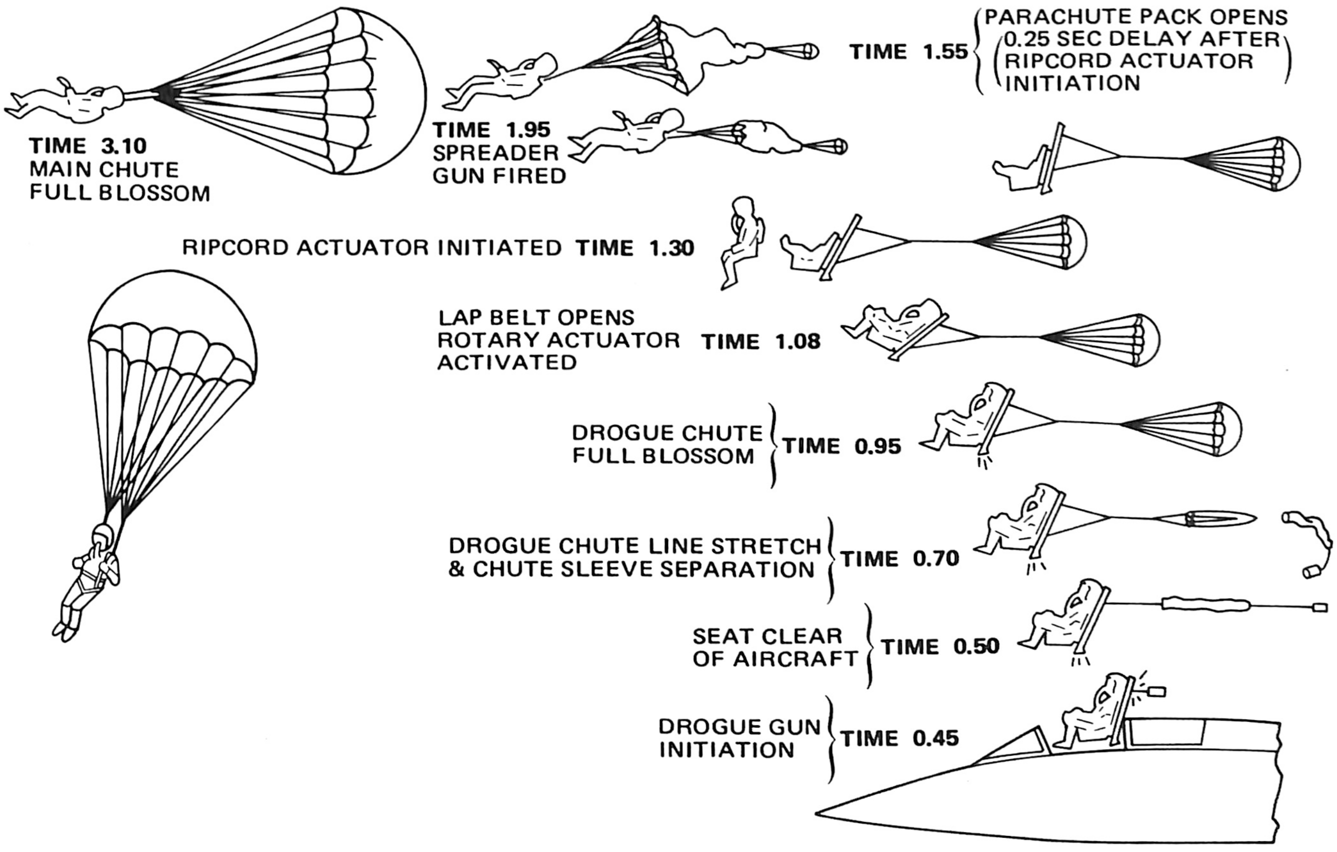

TIME 1.55 PARACHUTE PACK OPENS (0.25 SEC DELAY AFTER RIPCORD ACTUATOR INITIATION)
TIME 3.10 MAIN CHUTE FULL BLOSSOM
TIME 1.95 SPREADER GUN FIRED
RIPCORD ACTUATOR INITIATED TIME 1.30
LAP BELT OPENS ROTARY ACTUATOR ACTIVATED TIME 1.08
DROGUE CHUTE FULL BLOSSOM TIME 0.95
DROGUE CHUTE LINE STRETCH & CHUTE SLEEVE SEPARATION TIME 0.70
SEAT CLEAR OF AIRCRAFT TIME 0.50
DROGUE GUN INITIATION TIME 0.45

FIGURE A-27. EJECTION TIME AND EVENT SEQUENCE

## INERTIAL NAVIGATION SYSTEM

The AN/ASN-117 (Litton LN-33) inertial navigation system (INS) in the F-5E provides the pilots with a continuous readout of the aircraft present position and steering data to any of ten selectable destinations. The system has a specified accuracy of 1.5 nautical miles per hour CEP, an accuracy which was surpassed during the warranty demonstration flight test program. The INS replaces the attitude and heading reference system (AHRS) and provides attitude and heading information to the aircraft instruments and other systems as noted in Figure A-28. The INS consists of the following units:

- Inertial Navigation Unit (INU)
- Mounting Base, Electrical Equipment (MBEE)
- Control, Indicator (CI)
- Adapter, Inertial Navigation Unit (AINU)

The INS provides stabilized magnetic heading in normal operation and will provide unstabilized magnetic heading as a backup in event of a platform failure. The INS has a specified MTBF of 750 hours.

The INS CI is shown in Figure A-28. The INS operating modes are:

ALIGN

- Gyro-Compass — Alignment mode requires ten minutes for warmup and alignment and provides maximum navigation accuracy.
- Stored Heading — Alignment mode requires three minutes to align providing the system has previously been gyro-compass aligned prior to turnoff and the aircraft has not been moved. The navigation accuracy is degraded depending upon extent that the aircraft heading has been changed since the INS was gyro-compass aligned.

NAV

- Navigation mode — In this mode the system performs its navigation and attitude reference function providing that the system has completed a full-time gyro-compass alignment prior to switching to NAV mode.

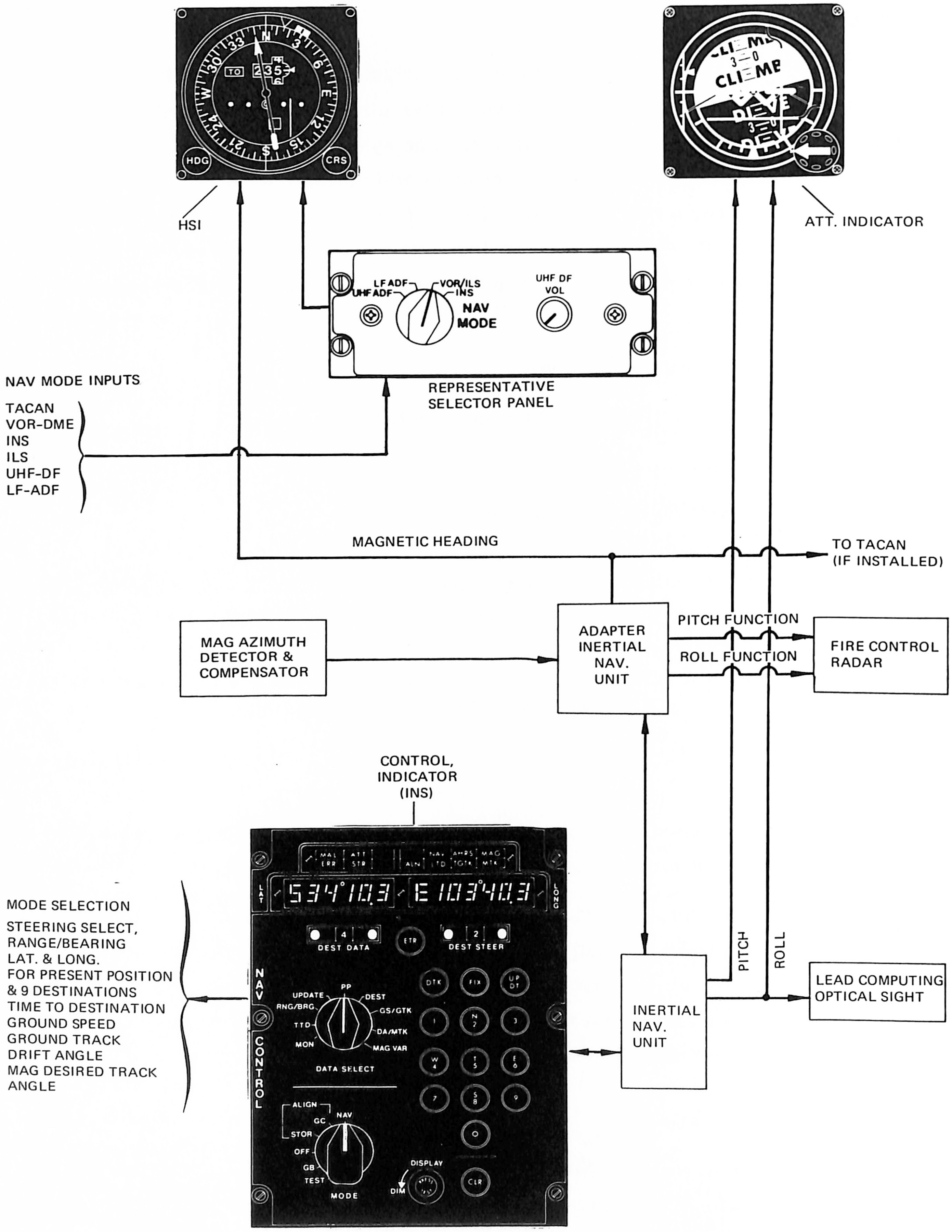

HSI
HDG
CRS
TO
ATT. INDICATOR
LF ADF
UHF ADF
VOR/ILS
INS
NAV MODE
UHF DF VOL
REPRESENTATIVE SELECTOR PANEL
NAV MODE INPUTS
TACAN
VOR-DME
INS
ILS
UHF-DF
LF-ADF
MAGNETIC HEADING
TO TACAN (IF INSTALLED)
MAG AZIMUTH DETECTOR & COMPENSATOR
ADAPTER INERTIAL NAV. UNIT
PITCH FUNCTION
ROLL FUNCTION
FIRE CONTROL RADAR
CONTROL, INDICATOR (INS)
MODE SELECTION
STEERING SELECT,
RANGE/BEARING
LAT. & LONG.
FOR PRESENT POSITION
& 9 DESTINATIONS
TIME TO DESTINATION
GROUND SPEED
GROUND TRACK
DRIFT ANGLE
MAG DESIRED TRACK
ANGLE
LAT
LONG
DEST DATA
DEST STEER
NAV CONTROL
UPDATE
PP
DEST
RNG/BRG
GS/GTK
TTD
DA/MTK
MON
MAG VAR
DATA SELECT
ALIGN
GC
NAV
STOR
OFF
GB
TEST
MODE
DISPLAY
DIM
CLR
PITCH
ROLL
INERTIAL NAV. UNIT
LEAD COMPUTING OPTICAL SIGHT

FIGURE A-28. INERTIAL NAVIGATION SYSTEM DIAGRAM

If the alignment period has been curtailed or if certain system failures occur, the system navigation and attitude reference functions are modified as indicated by status lights on the CI. These modified navigation modes are:

- AHRS Mode — Requires three minutes of alignment to erect the inertial platform and provides attitude and heading indication only.
- Limited NAV Mode — After approximately six minutes in gyro-compass alignment, the LTD status light will illuminate and if the system is turned to NAV, the system will navigate to a limited accuracy (five to six nautical miles per hour CEP).
- MAG Mode — Unstabilized magnetic heading is provided if the INS is turned off or if the platform fails.

The INS can be operated in basically four different steering modes:

- Range and Bearing Mode — If a destination is selected (DEST STEER) without selecting the desired track (DTK) to the destination, only the distance and relative bearing to the destination will be displayed on the horizontal situation indicator (HSI). The course deviation indicator (CDI) bar will be inoperative and the DEV flag on the HSI will be in view.
- Magnetic Track Steering Mode — A desired magnetic track (magnetic bearing previously entered into the computer) may be selected and steering information will be provided by the CDI bar on the HSI in addition to distance and relative bearing to destination. In this mode each dot on the CDI display represents five degrees from the desired magnetic track.
- Two Great Circle Track Steering Modes are provided:

  a. Present Position to Destination (DEST STEER)

  b. Waypoint (DEST DATA) to Destination (DEST STEER)

  In each of these modes, a great circle track to destination is inserted into the computer memory and steering information is provided on the CDI of the HSI. Each dot on the CDI display represents 5 nautical miles crosstrack from the desired track. The course marker on the HSI will be automatically positioned to indicate the magnetic equivalent bearing of the great circle track selected.

The CI has a built-in test feature which continuously monitors the operating status and will provide caution status lights on the CI if a malfunction occurs.

In addition, the system has features to minimize erroneous data insertion in the computer. If the operator tries to enter a latitude or longitude which is unreal, the ERR light will illuminate and the computer will not accept the data. Also, if the pilot attempts to update the system with a displacement error that is not reasonable, the computer will reject the update on the first try. However, if initiated a second time, the computer will accept the update.

Additional information provided by the CI is as follows:

- Range and bearing
- Time-to-destination
- Latitude and longitude of present position (or previously entered destination)
- Ground speed and ground track
- Drift angle
- Magnetic track (entered for selected destination)
- Magnetic variation

The INS has a self-test feature which may be used by ground personnel to determine the status of the system and to isolate malfunctions to the replaceable LRU. The only AGE for flight line use is a ground cooling blower provided for the INU when ambient temperatures are below 100°F. Above 100°F, conditioned air must be provided by operation of the onboard conditioning system.

## INSTRUMENT LANDING SYSTEM/FLIGHT DIRECTOR SYSTEM

The instrument landing system (ILS) installed in the F-5E operates in conjunction with ground based transmitters and with the flight director system to provide steering command indications for ILS approaches and attitude indications in all phases of flight.

### Instrument Landing System

The AN/ARN-108 instrument landing system (ILS) provides glide-slope, marker beacon and localizer functions. The major system components are the R-1871/ARN-108 Glide-Slope-Marker Beacon, and Localizer Radio Receiver, a C9445/ARN-108 ILS control panel (Figure A-29) in the forward left console of the cockpit, a marker beacon light in the instrument panel, a marker beacon antenna under the cockpit, a combination glide-slope/localizer antenna in the tailcap, and a glide slope/localizer antenna diplexer located adjacent to the marker beacon antenna. The localizer and glide-slope information is displayed on a horizontal situation indicator (HSI) and an attitude director indicator (ADI). These instruments are described under the description of the flight director system following.

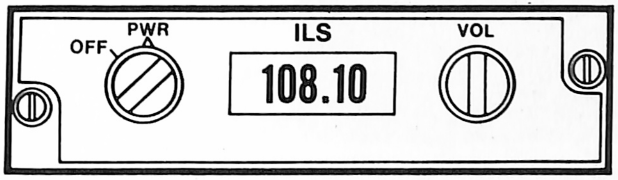
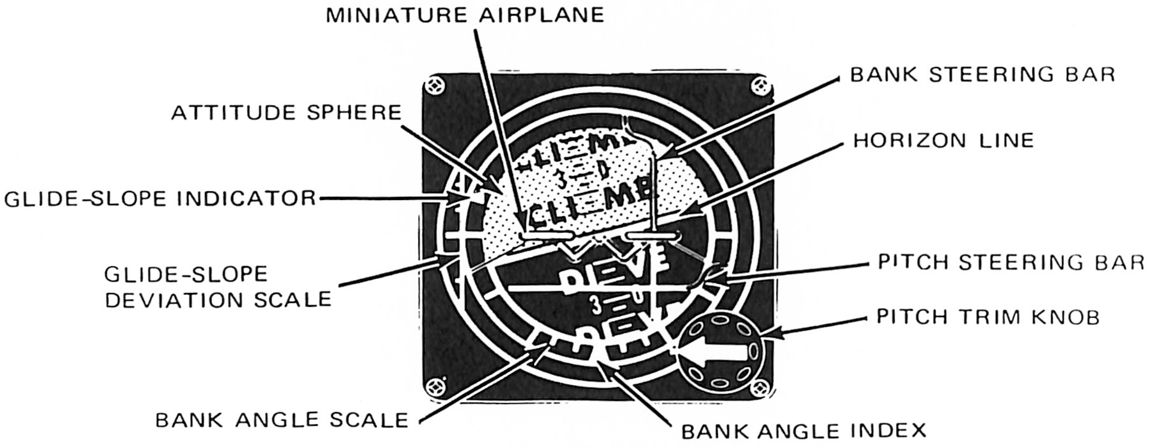
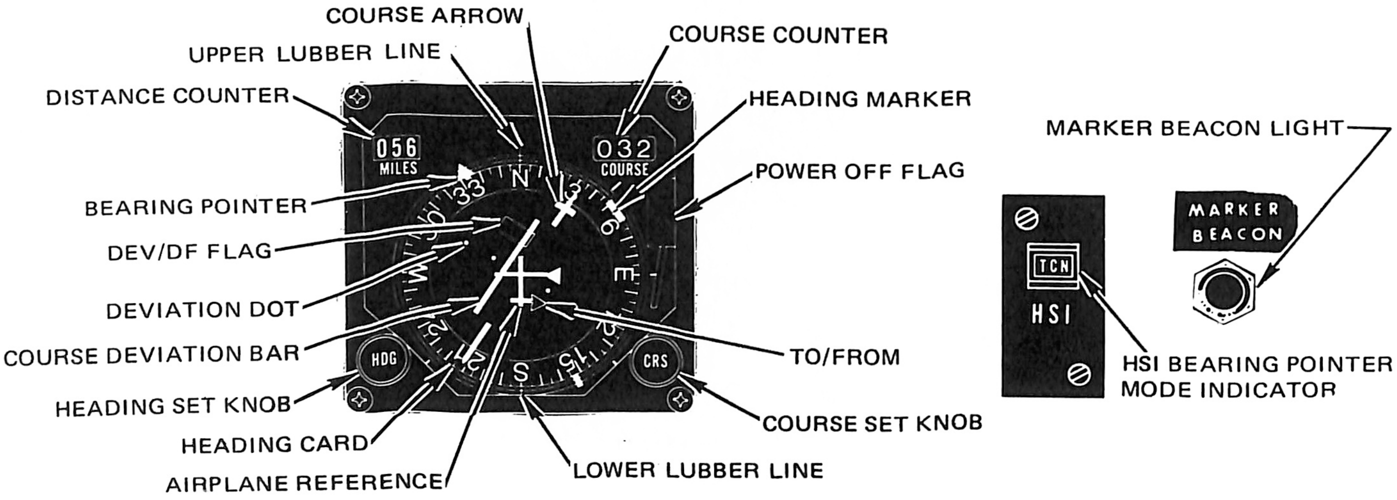


FIGURE A-29. ILS CONTROL PANEL

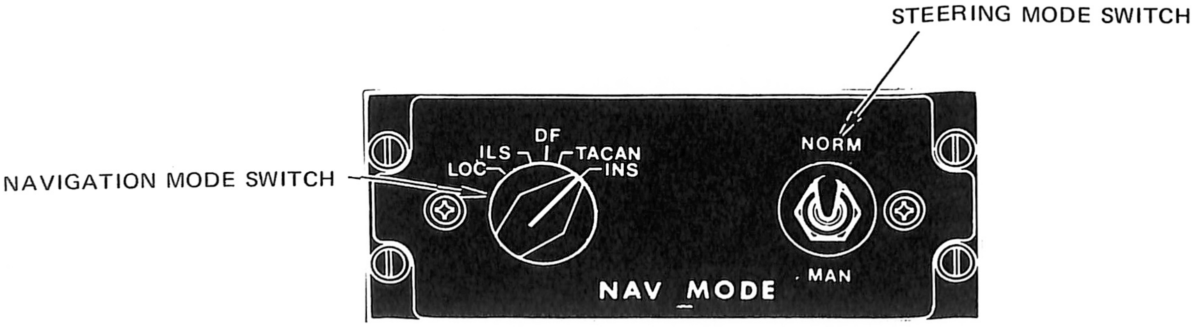
The indications on the cockpit instruments (Figure A-30) are such that deviation of the bank steering bar on the ADI and the course deviation indicator on the HSI will show the direction in which to fly to return to the desired heading. Deviation of the glide-slope indicator and the pitch steering bar on the ADI will show the direction and amount of pitch change necessary to return to the glide slope. The ILS glide-slope receiver provides vertical guidance indications and operates in the UHF range of 329.15 to 335.0 MHz. The ILS localizer receiver provides lateral guidance indications and identification signal reception, and operates in the VHF range of 108.1 to 111.95 MHz. When the localizer frequency is selected on the ILS control panel, the proper glide slope frequency is automatically selected. Localizer audio signals are controlled by the VOL (volume) knob on the ILS control panel. The marker beacon light on the instrument panel presents visual coded marker beacon indications during all modes of


MINIATURE AIRPLANE
ATTITUDE SPHERE
GLIDE-SLOPE INDICATOR
GLIDE-SLOPE DEVIATION SCALE
BANK ANGLE SCALE
BANK STEERING BAR
HORIZON LINE
PITCH STEERING BAR
PITCH TRIM KNOB
BANK ANGLE INDEX
CLIMB
DIVE

ATTITUDE DIRECTOR INDICATOR (ADI)


COURSE ARROW
UPPER LUBBER LINE
COURSE COUNTER
DISTANCE COUNTER
HEADING MARKER
POWER OFF FLAG
BEARING POINTER
DEV/DF FLAG
DEVIATION DOT
COURSE DEVIATION BAR
HEADING SET KNOB
HEADING CARD
AIRPLANE REFERENCE
LOWER LUBBER LINE
COURSE SET KNOB
TO/FROM
056
MILES
032
COURSE
HDG
CRS
N
E
S
W
33
6
12
15
21
24
30
MARKER BEACON LIGHT
MARKER BEACON
TCN
HSI
HSI BEARING POINTER MODE INDICATOR

HORIZONTAL SITUATION INDICATOR (HSI)


STEERING MODE SWITCH
NAVIGATION MODE SWITCH
LOC
ILS
DF
TACAN
INS
NORM
MAN
NAV MODE

NAVIGATION MODE CONTROL PANEL

FIGURE A-30. F-5E FLIGHT DIRECTOR SYSTEM DISPLAYS AND CONTROLS instrument operation. Passage of the aircraft directly over a marker beacon station will cause the marker beacon light to illuminate.

### Flight Director System (FDS)

The FDS provides the pilot with an integrated display of aircraft flight attitude and direction, and with steering signals to position the aircraft on a desired flight path.

The FDS consists of a NAD Spec 14-64951-1 flight director computer, an attitude director indicator (ADI), a horizontal situation indicator (HSI), a navigation mode switch and a steering mode switch. The system functions in conjunction with the inertial navigation system (INS), the ILS, and the TACAN system. The INS provides magnetic heading signals to the HSI, and pitch and roll signals to the ADI and the flight director computer.

The ADI and HSI display aircraft attitude, pitch and bank steering information, aircraft position relative to the ILS glide-slope, aircraft magnetic heading TACAN or localizer course deviation, and azimuth bearing, plus to-from indication of aircraft position with respect to a TACAN station. In addition, they provide power failure and signal inadequacy warning signals.

The localizer receiver supplies course deviation information to the HSI and localizer error signals to the flight director computer. The glide-slope receiver supplies glide-slope error signals to the flight director computer and glide-slope deviation information to the ADI.

The computer combines course error and heading error signals from the HSI, roll and pitch signals from the INS and glide-slope, and localizer signals from the glide-slope and localizer receiver to provide computed bank and pitch steering information. These enable the pilot to steer to asymptotically intercept the localizer and glide-slope beams. In addition, crosswind compensation is provided to establish the proper crab angle during ILS approaches.

The FDS is controlled by the navigation mode switch (Figure A-30) with selective positions placarded LOC (localizer), ILS, DF, TACAN, and INS and the steering mode switch with selective positions placarded NORM (normal) and MAN (manual).

## TACAN

The AN/ARN-84 is an improved TACAN system interchangeable with the AN/ARN-65 TACAN* system in both the F-5E and F-5F aircraft. It provides distance, bearing, and course information for aircraft navigation. The system operates in the L-band frequency range with 126 X-mode and 126 Y-mode channels available from 962 MHz to 1213 MHz. Nominal usable range of the system is approximately 200 nautical miles at an aircraft altitude of 40, 000 feet, or a proportionately lower range with decreased altitude. The AN/ARN-84 TACAN has several advantages over the AN/ARN-65 TACAN as follows:

- Provides both X and Y mode channels
- Provides air-to-air range data between similarly equipped aircraft
- Has Built-In-Test (BIT) capability
- Features solid state electronics
- Has improved reliability with a specified MTBF of 1000 hours

In addition to the above features, the equipment performs the following functions:

- Displays relative bearing to the ground beacon continuously in the receive (REC) and transmit-receive (T/R) modes.
- Indicates aircraft deviation from the selected course or ground beacon radial in the REC and T/R modes.
- Indicates the distance (slant range) of the aircraft to the ground beacon in the T/R mode.
- Provides a signal to indicate whether the selected course takes the aircraft toward or away from the beacon in the REC and T/R modes.
- Identifies the ground beacon station being received by aural indication which is controlled through the aircraft intercom system.

The system consists of a receiver/transmitter (RT), a TACAN set control, TACAN tone filter and the antenna system. The RT is located in the forward equipment bay and the TACAN set control (Figure A-31) is located in the center pedestal (both cockpits in the F-5F).

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*A description of the AN/ARN-65 TACAN can be found in Section 4.

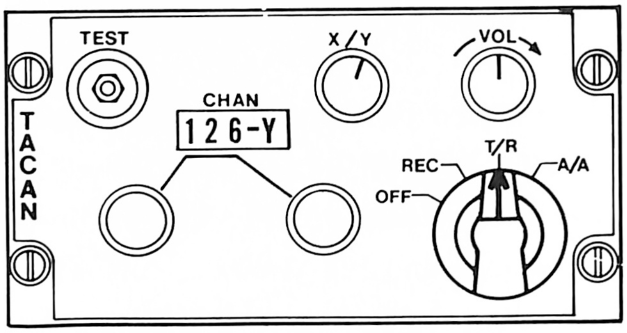


FIGURE A-31. TACAN SET CONTROL

Controls consist of channel selectors, X/Y mode channels, volume, mode selection; and self-test. The mode selector switch is a four-position rotary switch marked OFF, REC, T/R, and A/A. In the REC position, the receiving circuits in the R/T are energized to provide bearing information and ground beacon identity only; the T/R position energizes both the receiving and transmitting circuits in the R/T to provide bearing, deviation, beacon identity, to/from and distance information. When the function switch is in the A/A position, it is possible to obtain air-to-air range between the F-5E/F and other aircraft equipped with the air-to-air mode capability. An operable system is confirmed by depressing the TEST button and observing that the HSI indicates 180 degrees and a range of zero nautical miles.

The aural identification signal is fed directly from the receiver to the intercommunication system. When the TACAN and IFF/SIF systems are in operation, the transmitting system of each generates blanking pulses to prevent spurious operation of the other system.

TACAN information is displayed on the HSI and includes aircraft heading, to/from station information; TACAN bearing and range, preset course, and course deviation information. Displayed range information is accurate to 0.15 nautical miles, and the displayed magnetic bearing information is accurate within one degree.

The TACAN antenna system consists of two directional L-band antennas; one is a horizontal slot in the vertical stabilizer for aft coverage and the other is a blade antenna mounted on the lower forward fuselage for forward hemispheric coverage. A radio frequency transmission switch connects the R/T to the antenna system. The R/T controls the switch, which automatically selects either the TACAN forward or aft antenna.

## LOW FREQUENCY ADF

The low frequency Bendix DFA-74A automatic direction finder (ADF) system installed in the F-5E aircraft is an airborne radio navigational aid that furnishes audio reception and relative bearing indications of broadcast stations and low frequency navigation stations within the frequency range of 190 to 1749.5 KHz.

The system consists of the following installations:

- An ADF receiver located on the F-5E cockpit shelf behind the pilot for aircraft with the INS or in the aft pressurized compartment for aircraft with AHRS system. The receiver is Model DFA-74A manufactured by Bendix Corp. An optional receiver, Model 51Y-7 (DF-206 ADF System), manufactured by Collins Radio Co. is also available. The two receivers are interchangeable.
- A sense antenna and matching sense antenna coupler located in the dorsal area forward of the vertical stabilizer.
- A flush-mounted loop antenna and matching quadrontal error corrector located underneath the aircraft aft of FS 400.
- A dual ADF control panel (Figure A-32) located in the center pedestal (both cockpits in the F-5F).
- A NAV Mode control panel (Figure A-33) located in the center pedestal (both cockpits in the F-5F).

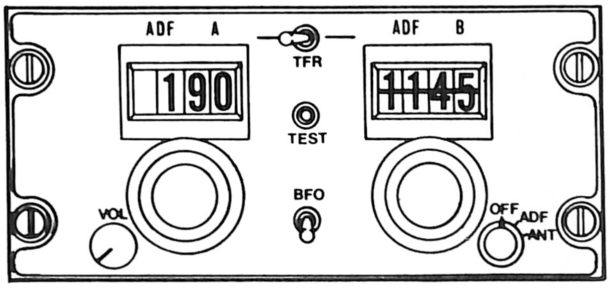


FIGURE A-32. DUAL ADF CONTROL PANEL

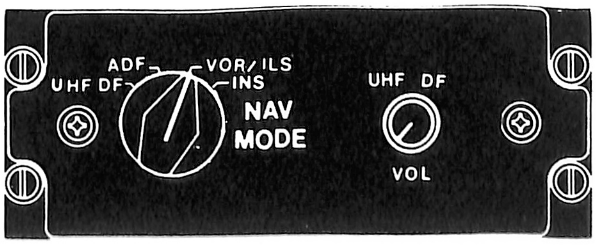


FIGURE A-33. NAV MODE CONTROL PANEL

The ADF panel has two frequency selector knobs which allow selection of two (2) ADF frequencies. A TFR switch on the control panel allows rapid switching between frequencies. The receiver audio output is fed into the intercommunication system and the audio gain is controlled by the volume control. The panel also includes a beat frequency oscillator (BFO) switch, a selector switch for OFF, ADF and ANT (receive) modes, and a test switch. The BFO switch provides an audible tone when the receiver is tuned to an unmodulated carrier.

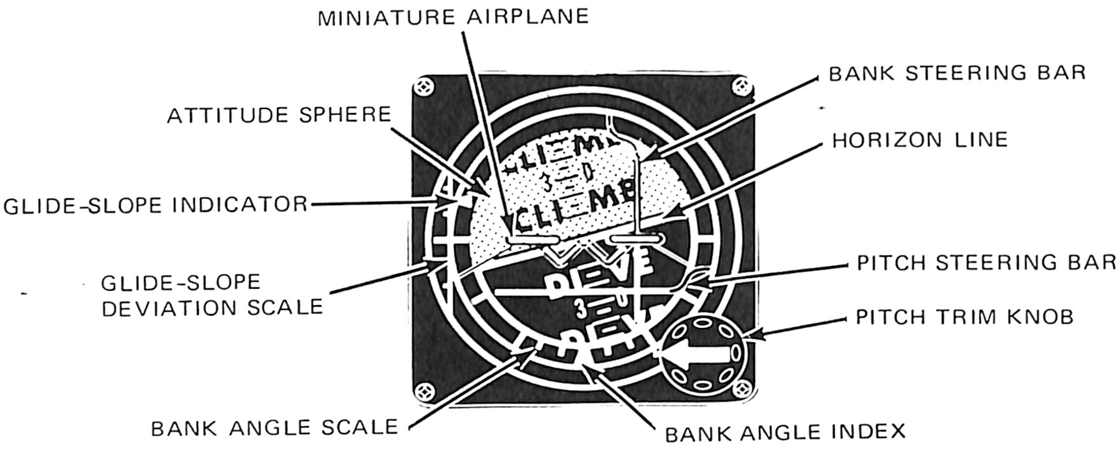
The ADF system is tied into the NAV MODE control panel which connects the ADF relative bearing information to the Horizontal Situation Indicator (HSI). When the ADF system is operating, actuation of the TEST switch introduces a 90-degree bearing signal and the HSI bearing pointer indicates a 90-degree bearing if the LF ADF system is operating properly.

## VOR-ILS-DME SYSTEM

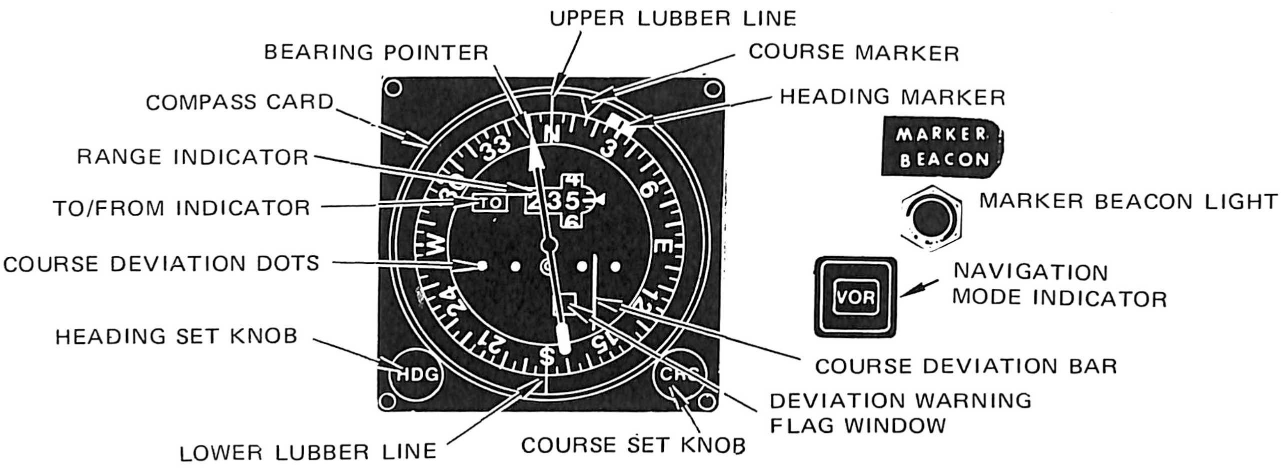
The VOR-ILS-DME system installed in the F-5E aircraft provides VOR navigation, ILS localizer, glide slope, marker beacon, and distance measuring information with associated flag signals, station to-from indication, range indication and VOR/LOC audio outputs. This system is installed in place of the TACAN system.

The system consists of the following assemblies (system controls and displays are shown in Figure A-34):

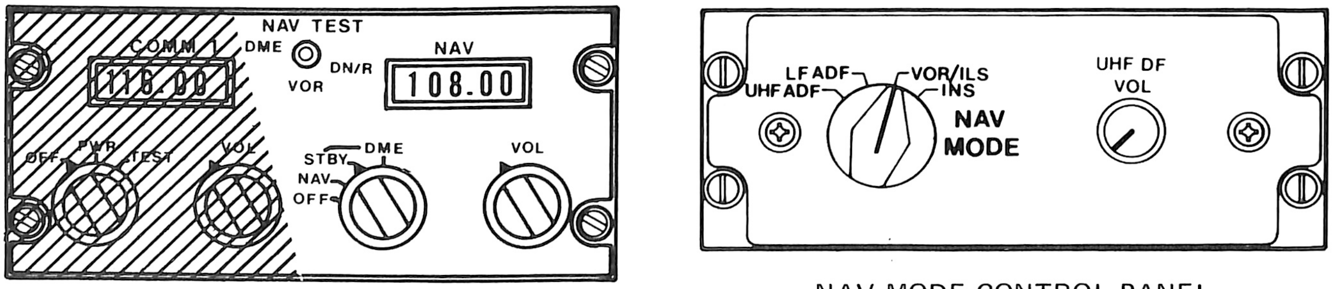
- A Collins VIR-31A navigation receiver containing the VOR, localizer, glide slope, and marker beacon functions. The receiver is installed in the forward avionics compartment on a combination shock mounted rack which also supports the DME transponder.
- A combination VOR/LOC/Glide slope antenna assembly located on top of the vertical stabilizer.
- An antenna diplexer located under the floor of the cockpit. The diplexer separates radio frequency signals from the antenna into a VOR/LOC signal and a glide slope signal.
- A marker beacon antenna located beneath the cockpit.
- A marker beacon indicator light located on the instrument panel adjacent to the Horizontal Situation Indicator (HSI).
- A Collins DME-40 receiver-transmitter mounted with the VIR-31A receiver in the forward avionics compartment.
- A DME blade antenna with ground test jack located beneath the forward avionics compartment.
- A DME antenna located in the upper trailing edge of the vertical stabilizer.
- A C-4808 antenna selector (with power relay and special oscillator) located in the forward avionics compartment.
- A Digital-to-Analog converter unit located in the forward avionics compartment.
- A combination COMM/NAV dual control panel located in the center pedestal.
- A NAV Mode control panel located in the center pedestal.
- An attitude director indicator (ADI), located on the left instrument panel in place of the attitude indicator.


MINIATURE AIRPLANE
BANK STEERING BAR
ATTITUDE SPHERE
HORIZON LINE
GLIDE-SLOPE INDICATOR
CLIMB
DIVE
GLIDE-SLOPE DEVIATION SCALE
PITCH STEERING BAR
PITCH TRIM KNOB
BANK ANGLE SCALE
BANK ANGLE INDEX

ATTITUDE DIRECTOR INDICATOR (ADI)


UPPER LUBBER LINE
BEARING POINTER
COURSE MARKER
COMPASS CARD
HEADING MARKER
MARKER BEACON
RANGE INDICATOR
MARKER BEACON LIGHT
TO/FROM INDICATOR
TO
235
N
3
6
E
12
15
S
21
24
W
33
COURSE DEVIATION DOTS
NAVIGATION MODE INDICATOR
VOR
HEADING SET KNOB
HDG
CRS
COURSE DEVIATION BAR
DEVIATION WARNING FLAG WINDOW
LOWER LUBBER LINE
COURSE SET KNOB

HORIZONTAL SITUATION INDICATOR (HSI)


COMM
116.00
NAV TEST
DME
VOR
DN/R
NAV
108.00
OFF
PWR
TEST
VOL
STBY
DME
NAV
OFF
VOL
LF ADF
UHF ADF
VOR/ILS
INS
NAV MODE
UHF DF VOL

COMM/NAV DUAL CONTROL PANEL

NAV MODE CONTROL PANEL

FIGURE A-34. VOR-ILS-DME SYSTEM CONTROLS AND DISPLAYS

- A horizontal situation indicator (HSI) with an additional heading marker and heading set knob (Figure A-34) in place of the basic HSI.

The system is controlled by the mode selector switch on the NAV MODE control panel and the controls on the NAV portion of the COMM/NAV control panel. The receiver is on when the selector switch on the COMM/NAV panel is in any position except OFF. Frequency selection is accomplished by use of the NAV-STBY-DME (NSD) and VOL controls. These are both dual controls with coaxial outer and inner knobs. The inner knob of the NSD control is used to select the whole digits and the inner knob of the VOL control is used to select the decimal digits of the desired frequency. If the NSD switch is at the NAV position, frequency selection is between 108.00 MHz and 111.90 MHz, and the NAV Mode selector is set at VOR/ILS, the ILS localizer and glide slope functions are displayed on the HSI and on the ADI. When frequency selection is between 112.00 MHz and 117.95 MHz, VOR navigation information will be displayed on the HSI. If DME is then selected on the NSD control, the DME distance readout will also be displayed on the HSI. The readout is available only when the VIR-31A receiver is tuned to a VOR ground station. Anytime the VIR-31A receiver is on, DME distance information can be displayed on the HSI even when the NAV Mode selector switch is in the ADF position.

Marker beacon signals to the indicator light are provided anytime the VIR-31A receiver is on. The volume control on the COMM/NAV control panel controls audio level of the LOC or VOR audio signals. The NAV TEST control is a toggle switch with a center off position; the up position tests the DME, and the down position tests the VOR.

The DME system provides continuous slant range distance information from the aircraft to selected ground stations. It operates in conjunction with either VOR/DME, VORTAC or TACAN ground stations. When VOR stations are selected on the COMM/NAV control panel, the DME is automatically tuned to the proper DME frequency associated with the VOR channel selected. Range capability is nominally 200 miles with one-tenth mile accuracy. The DME-40 features a built-in memory of twelve seconds to hold the DME readout if reliable signal is momentarily lost.

## VHF COMMAND RADIO

The Collins VHF-20A communications system* installed in the F-5E aircraft provides two-way voice communications at line-of-sight ranges. The Collins VHF-20A receiver-transmitter (R/T) unit operates in the frequency range between 117.000 to 135.950 MHz with 16 watts rated minimum RF power output during transmissions. Channel centers are separated by 50 KHz providing 380 channels per receiver.

The system consists of two separate VHF-20A R/T's located in the forward avionics compartment and shock mounted to operate in the gun-firing environment. In addition, the system includes a combination 313N-3D VHF COMM and NAV set control located in the center pedestal of the cockpit for VHF number one, a single set control 313N-4A located in the center pedestal for control of VHF number two, a VHF blade antenna located on the dorsal just aft of the cockpit, an SA-521 coax switch located in the left forward avionics compartment near the two R/T units for switching the antenna between the two R/T units, and a COMM SELECT switch located adjacent to the VHF number two set control in the center pedestal for selecting the desired R/T unit. The set controls are shown in Figure A-35.

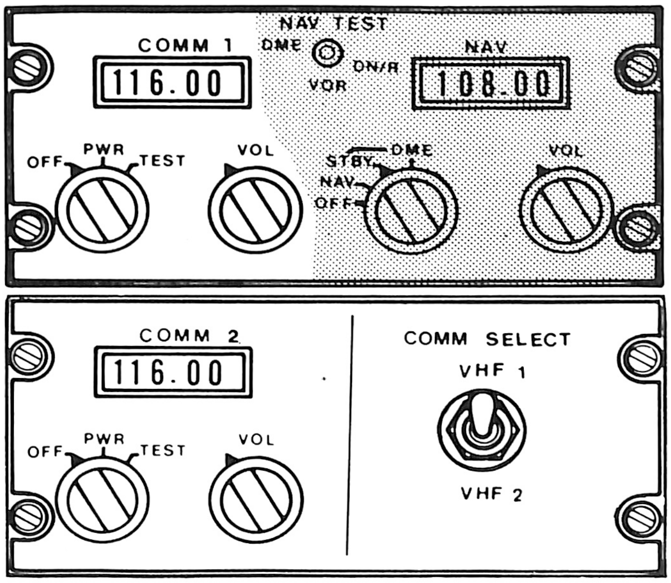


FIGURE A-35. RADIO SET CONTROLS

Each set control has an OFF-PWR-TEST (OPT) control knob. During operation both set controls will be in the PWR position but only the R/T unit selected will have 28 volts dc power applied to it. Transmission and reception can only be effected on the

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*The basic ARC-150 UHF radio is described in Section 4.

VHF R/T selected. Each set control has a VOL control which controls the audio level of its R/T unit. Frequency selection is accomplished by use of the OPT and VOL controls. These are both dual controls with coaxial outer and inner knobs. The inner knob of the OPT control is used to select the whole digits and the inner knob of the VOL control is used to select the decimal digits of the desired frequency. Two different frequencies can be set up, one on each set control, to provide quick change from one frequency to the other by switching the COMM SELECT switch between VHF 1 and VHF 2. The VHF antenna is automatically connected to the R/T unit that is selected. When the TEST position is selected on either receiver, the squelch is disabled allowing the operator to detect a good receiver by observing the presence of receiver noise.

## ALTERNATE UHF COMMAND RADIO SET

The RT-1168/AN/ARC-164(V) receiver transmitter is an alternate to and a scheduled replacement for the existing AN/ARC-150(V)9 radio set described in Section 4. The system is equivalent to the ARC-150 in mechanical form and operational function. It covers a frequency range from 225.0 MHz to 399.975 MHz. It has 7000 channels with spacing between channels of 25KHz. The set provides an electronic preset channel memory that provides for the storage of 20 of the 7000 available channels and single selector switch that permits selection of any one of the 20 channels. Presetting is accomplished from the front of the control panel without requiring removal of the radio set from the mounting. The memory is of the non-destruct type and is capable of storing the required preset channel information indefinitely without the necessity of recharging or restoring the information.

The guard channel receiver is capable of being tuned over a frequency range from 238.0 MHz to 248.0 MHz. Automatic antenna selection with a manual override capability is provided. Automatic antenna selection of either forward or aft antenna is determined as a function of best reception.

The RT-1168/AN/ARC-164(V) receiver transmitter has, as a design objective, a 1000 hour MTBF. It operates without special cooling air. Installation is similar to the existing AN/ARC-150(V)9 radio. Figure A-36 illustrates the AN/ARC-164 control panel.

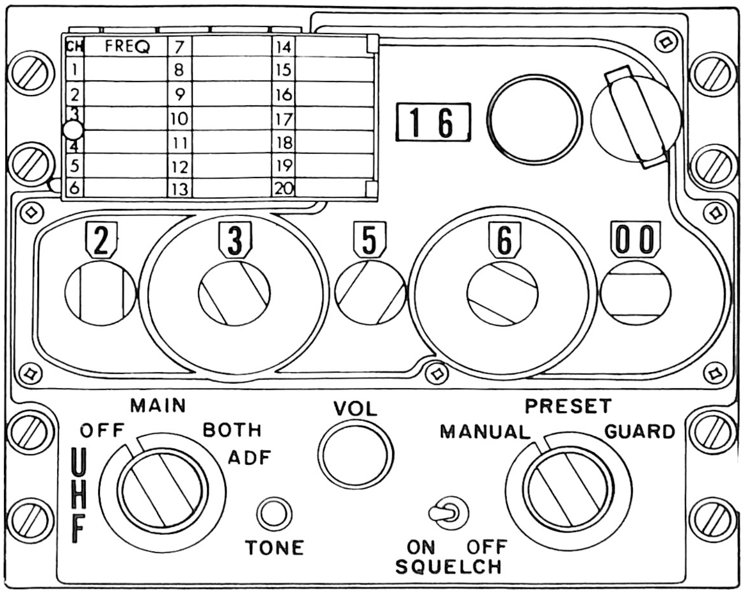

FIGURE A-36. AN/ARC-164 CONTROL PANEL

## ALTERNATE IFF/SIF SYSTEM

The AN/APX-101 IFF/SIF (identification friend or foe/selective identification feature) is an alternate system to the APX-72 described in Section 4. Improvements offered by the APX-101 over the existing APX-72 are frequency diversity, the capability of automatically distinguishing which channel, upper or lower, should be used for transmitting replies upon interrogation and an automatic self-contained, self-test subsystem. It provides positive identification of an aircraft, whenever challenged by a ground, shipboard, or airborne IFF recognition installation (RI) and provides automatic altitude reporting in 100-foot-increment data obtained from the central air data computer (CADC). Upon receipt of an RI challenge, the system decodes the interrogating signal, encodes a reply and automatically transmits the coded reply back to the RI where it is visually displayed on an indicating device such as a search-radar plan position indicator. The system receives and transmits Mark X-IFF signals supplemented by the selective identification feature. Four operating modes are available: M-1 provides 32 pilot selectable military codes, M-2 provides 4096 military codes, and Mode C provides automatic altitude reporting of corrected pressure altitude computed by the CADC. Complete provisions for a KIT-1A/TSEC computer are incorporated in the aircraft for Mode 4 (classified) security identity. Receiver and transmitter operation occurs in the ultrahigh-frequency bands, limiting usable range to line of sight between the airplane and the RI.

Components of the system include an RT-1063/APX-101 radio, receiver/transmitter, C-2680(P)/APX transponder set control, two L-band antennas, and two antenna test receptacles. The system is operated from the aircraft dc power system. The transponder is hermetically sealed and requires no cooling air while operating over the temperature range of -54°C to +71°C. Maintenance procedures are simplified because the transponder contains throwaway RF components instead of tubes, and the need for realignment is minimized. The unit is estimated to have an MTBF of 500 hours. The transponder set control which is mounted in the cockpit (front cockpit only in the F-5F), provides remote control of the system. Located on the front panel of this unit (Figure 4-67 in Section 4) are two knob-actuated rotary switches, eight toggle switches and six thumbwheel-actuated rotary switches. The thumbwheel switches are used to select reply code numbers to interrogation modes 1 and 3 for the transponder. Each mode-enabling toggle switch has a momentary TEST position which permits a comparison of simulated interrogation signals with the resulting replies. Favorable comparisons are indicated by illumination of the TEST light.

The MASTER rotary switch turns the transponder on or off, controls transponder receiver sensitivity, and provides for manual selection of the emergency code transmission.

Aircraft equipped with a KIT-1A/TSEC computer are capable of being preset with a Mode 4 classified discrete frequency. The IFF caution light on the caution light panel comes on when Mode 4 interrogations are not properly processed and replied to or when Mode 4 is zeroed.

The AN/APX-101 is capable of frequency diversity operation and includes the necessary circuitry for the purpose of distinguishing which channel, upper or lower, should be used for transmitting replies, provided the difference in time is less than 0.2 microseconds. The system allows replies to SIF interrogations on the antenna receiving the SIF interrogations between the Mode 4 interrogations and the Mode 4 reply. The system also permits replies to the Mode 4 interrogation on the same antenna on which the Mode 4 interrogations were received in the presence of interlaced SIF interrogations.

The IFF antenna system consists of two directional antennas; one is a horizontal slot in the vertical stabilizer for aft hemisphere coverage and the other is the L-band portion of the combination UHF/IFF blade antenna mounted on the lower forward fuselage for forward hemisphere coverage. Each antenna has a ground test receptacle, and a three-position IFF test switch selects either FORWARD ANTENNA, AFT ANTENNA, or BOTH for ground test of the IFF system. This switch is located on the seat rail structure behind the pilot's head in the F-5E and in the same relative location behind the rear cockpit seat in the F-5F. The system incorporates the functions of the IFF Test Set and Lobing switch which are used with the APX-72 system.

## RADAR WARNING RECEIVER

The AN/ALR-46(V)2 modified radar warning receiver (RWR) provides airborne search, detection, analysis, relative range and direction finding of enemy radar signals received by the system. It displays visual warning signals on the azimuth indicator and threat display unit. Simultaneous audio warning is provided on the aircraft intercommunication system.

The RWR system consists of four spiral antennas, four amplifier detectors, an analyzer, an azimuth indicator, a threat display unit, a remote threshold control, a blade antenna and a countermeasures receiver. Figure A-37 presents a block diagram of the RWR system. Two spiral antennas are located on the lower forward nose and two are located on the sides of the aft fuselage to provide 360° coverage. Two amplifier detectors are located in the avionics bay and two are located on the upper aft fuselage as close as possible to their associated antennas to minimize cable losses. The analyzer is located in the avionics bay. The azimuth indicator and the threat display unit are located on the upper right side of the cockpit instrument panel and provides visibility and accessibility to the controls. The remote threshold control is located on the left cockpit console. The countermeasures receiver is located in the avionics bay and its associated blade antenna is located on the lower forward fuselage. Figure A-38 presents a picture of the major system components.

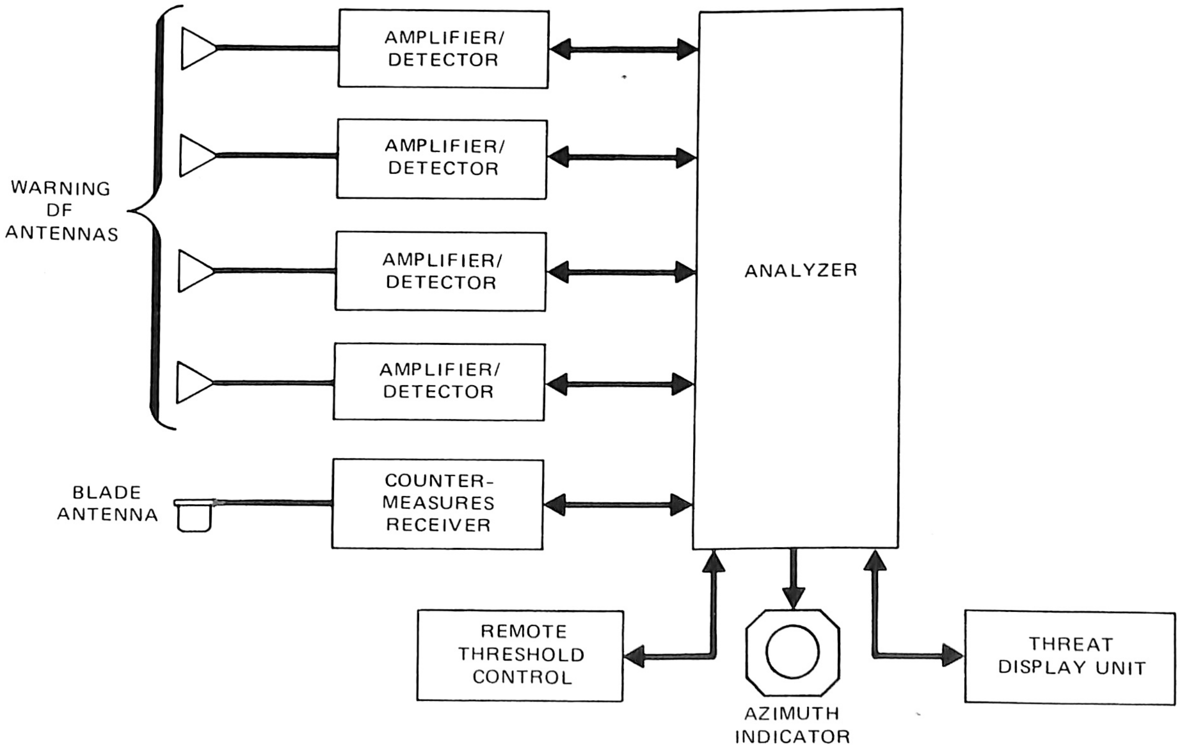
WARNING
DF
ANTENNAS
AMPLIFIER/ DETECTOR
AMPLIFIER/ DETECTOR
AMPLIFIER/ DETECTOR
AMPLIFIER/ DETECTOR
BLADE ANTENNA
COUNTER- MEASURES RECEIVER
ANALYZER
REMOTE THRESHOLD CONTROL
AZIMUTH INDICATOR
THREAT DISPLAY UNIT

FIGURE A-37. AN/ALR-46 RWR BLOCK DIAGRAM

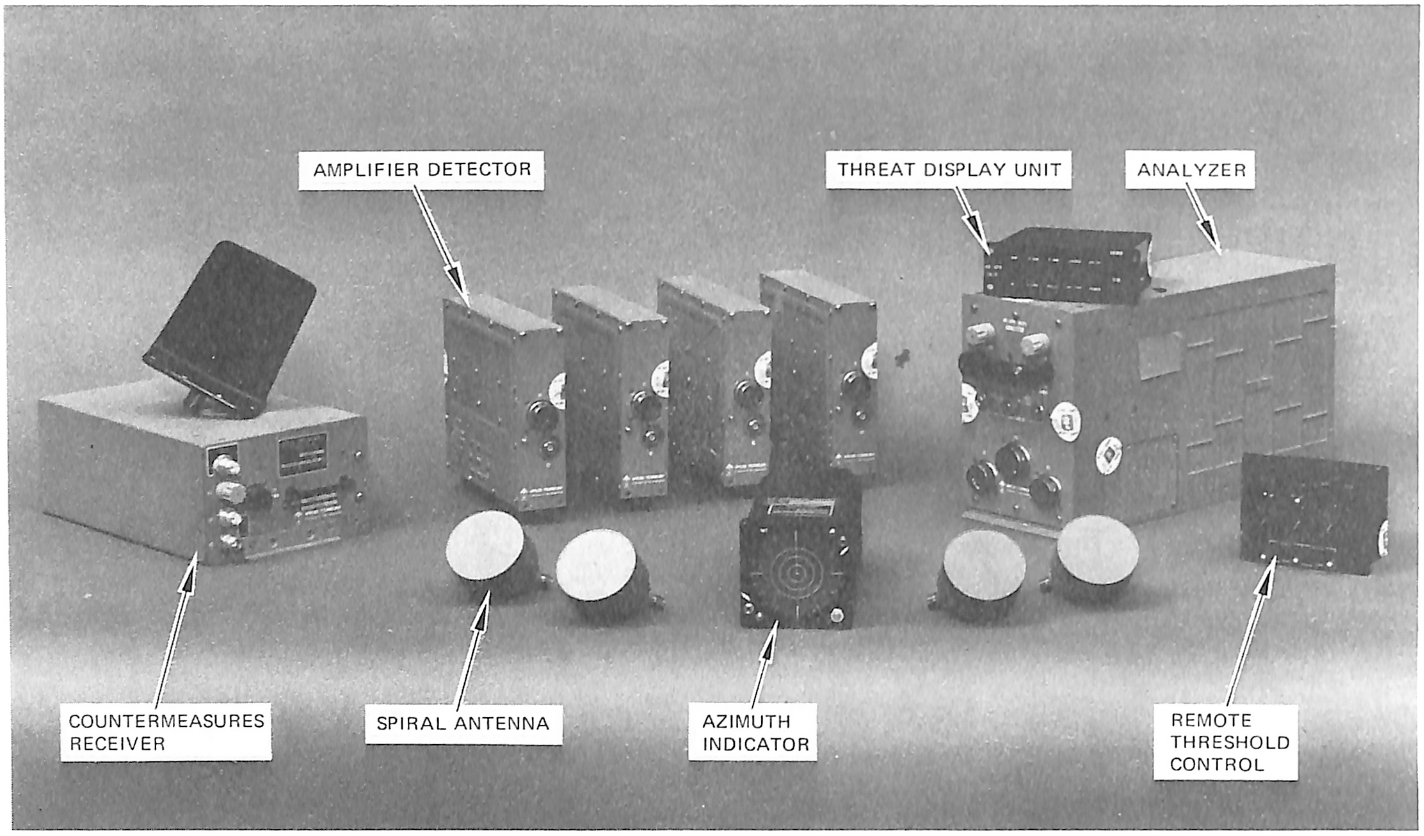
AMPLIFIER DETECTOR
THREAT DISPLAY UNIT
ANALYZER
COUNTERMEASURES RECEIVER
SPIRAL ANTENNA
AZIMUTH INDICATOR
REMOTE THRESHOLD CONTROL

FIGURE A-38. AN/ALR-46(V)-2 (MOD) MAJOR COMPONENTS

The four spiral antennas are oriented in azimuth at 45, 135, 225, and 315 degrees with respect to the aircraft longitudinal axis. Each amplifier detector receives the signal from its respective antenna and provides frequency discrimination and amplification. The signal is then applied to the analyzer. The analyzer provides threat identification and processes the signal to a format suitable for display on the azimuth indicator and on the threat display unit.

The detected threat radar signals are displayed on the azimuth indicator as radial strobes which provide relative bearing and relative signal strength. Visual threat warning and identification are provided by illumination of legend coded lamps in the threat display unit. Aural threat warnings are also provided by audio tones in the pilot's headset. The remote threshold control provides selection of automatic or manual control of system sensitivity. The blade antenna and its associated countermeasures receiver provides detection of SAM activity signals. The RWR receives blanking signals from the aircraft onboard radar, TACAN, and IFF/SIF through the blanking electronics unit.

The Blanking Electronics Unit (BEU) provides electrical interfaces with the radar warning receiver, IFF/SIF and the TACAN to reduce mutual interference of these systems. The BEU is a single unit located in the avionics bay. The unit receives suppression pulses from the radar, IFF/SIF and TACAN and provides conditional blanking pulses to the RWR in addition to the TACAN and IFF/SIF systems.

## MAVERICK MISSILE CAPABILITY

The Maverick missile is an air-to-ground weapon optimized for use against hard point targets such as tanks, bunkers, or gun emplacements. The missile has an optical contrast tracking guidance system which is locked on the target prior to launch. It is a "fire and forget" system which leaves the pilot free to take evasive action immediately after launch. The warhead uses a shaped charge for maximum armor penetration. It also has sufficient blast and fragment output to be effective against bunker class targets. A Maverick missile can be carried on each of the four F-5E/F wing stations.

The Maverick missile, shown in Figure A-39, is 12 inches in diameter, 98 inches in length and has a maximum fin span of almost 30 inches. It weighs 460 pounds. The missile produces a very high kill probability against hard point targets when the minimum conditions of daylight and target contrast are met.

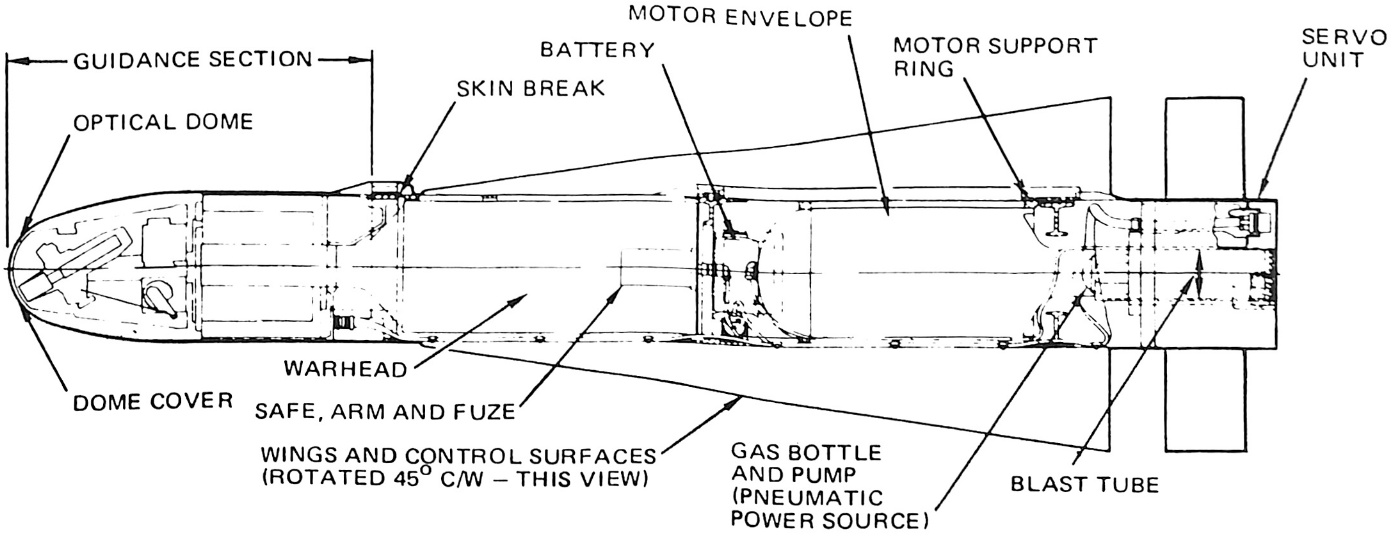
MOTOR ENVELOPE
BATTERY
MOTOR SUPPORT RING
SERVO UNIT
GUIDANCE SECTION
SKIN BREAK
OPTICAL DOME
WARHEAD
DOME COVER
SAFE, ARM AND FUZE
WINGS AND CONTROL SURFACES (ROTATED 45° C/W – THIS VIEW)
GAS BOTTLE AND PUMP (PNEUMATIC POWER SOURCE)
BLAST TUBE

FIGURE A-39. MAVERICK MISSILE – CUTAWAY DRAWING

The F-5E/F Maverick system consists of Maverick peculiar elements integrated with other on-board systems. Compatible interfaces allow effective sharing of common elements.

### Maverick Peculiar Elements

Standard production AGM-65A Maverick missiles.

Single Rail Launcher with self contained electronics. The launcher, Figure A-40, is 93.5 inches long and weighs approximately 125 pounds. The launcher electronics are contained in a separate LRU which includes the necessary power supply, logic, and timing circuits. Proven solid state devices with very high reliability and low power consumption are used.

Maverick Panel– the panel provides certain Maverick unique control functions.

Maverick Interface Control Unit – the interface control unit provides logic, switching, distribution, and interconnecting functions related to Maverick interfaces with the armament control, display indicator, scan converter, and cockpit control functions.

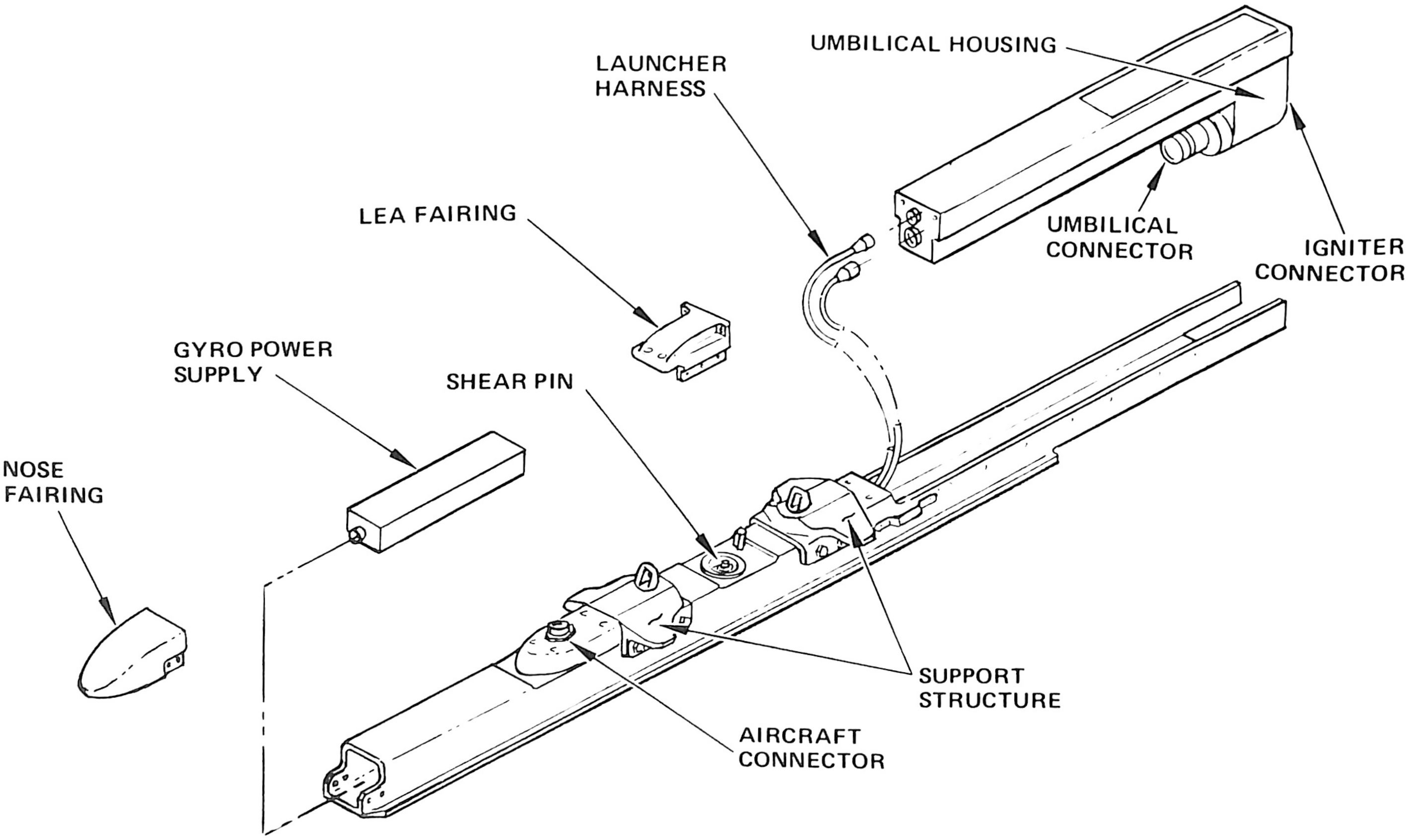
UMBILICAL HOUSING
LAUNCHER HARNESS
LEA FAIRING
UMBILICAL CONNECTOR
IGNITER CONNECTOR
GYRO POWER SUPPLY
SHEAR PIN
NOSE FAIRING
SUPPORT STRUCTURE
AIRCRAFT CONNECTOR

FIGURE A-40. F-5E/F MAVERICK LAUNCHER DETAILS

## Interface Equipment

Video Display Indicator – the video display, a high performance cathode ray tube which is used to display the Maverick video, has sufficient brightness for use in direct sunlight. A large 4.5 inch square aperture is used. The display replaces the radar indicator in the F-5E vertical console. Displays are provided in both cockpits of the F-5F.

Scan Converter – a radar scan converter is required to provide a dual mode radar/Maverick display. This is a solid state device of high reliability which processes the radar signals for display on the cathode ray tube. The by-products of this signal processing include an increase in radar detection and lock-on range and a selectable 2:1 magnification of the video field of view. The scan converter is located in the forward avionics compartment above the TACAN receiver/transmitter.

Hand Control – a two-axis hand control is required to manipulate the Maverick seeker in azimuth and elevation to align the tracking gate to the target. A tracking gate reticle is projected on the video display to provide the necessary reference for alignment. In order to make the most efficient use of cockpit space, the radar hand control is used to control the Maverick. This control is in the left hand horizontal console (both cockpits in F-5F).

Armament Control – modifications must be made to the armament control system to provide for the additional functions of AGM-65 select, station select, jettison, missile ready, and launch.

Cockpit Switchology – the controls for the Maverick missile are integrated with other avionics systems to provide a consistent task/function relationship. The detailed placement of switches and controls is dependent on the total cockpit requirements for specific aircraft configurations.

## F-5F Configuration

Full Maverick capability is provided in both cockpits of the F-5F except that the rear cockpit does not have an armament panel or gunsight and therefore does not have weapon select, station select, or visual acquisition capabilities.

## IMPROVED FIRE CONTROL SYSTEM

The F-5E/F improved fire control system provides increased target detection range, off-boresight acquisition, and angle tracking in addition to all the basic APQ-153/APQ-157 radar and fire control system functions described in Section 4. Addition of frequency agility and a flat plate antenna result in reduced clutter, "second time around echo" (STAE), altitude line, and "hat section" ground return interference. Sight-head pipper slaving permits the pilot to approach to within 10 degrees of boresight head-down using the radar display and then go head-up and have the slaved pipper on the LCOSS designate the target. A dogfight missile/gun, resume-search switch on the control stick permits the transfer from gun mode to missile mode without going to resume-search, providing greater attack flexibility. The relationship between the F-5E and F-5F systems is the same as for the basic APQ-153/APQ-157 radar systems as described in Section 4.

The F-5E/F improved AN/APQ-153 (TBD)/AN/APQ-157 (TBD) radar is a lightweight, X-band, air-to-air, search-and-track, fire control radar (FCR). The system modes of operation are standby, search, missile, guns, and test. The standby and test modes are unchanged from the basic APQ-153/APQ-157 radar.

Search Mode. The search mode has an added 40-mile range scale (in addition to the 5, 10, and 20-mile scales) to permit long range large target detection. An automatic one bar scan and elimination of the fast-time-constant occur when switching to the 40-mile scale.

Missile Mode. When a target is detected, the acquisition gate is moved via the target designation control to bracket the target. Acquisition (ACQ) is initiated by pushing the ACQ button on the radar set control. This causes the antenna to slew to the acquisition gate position and search a 10 degrees elevation by 15 degrees azimuth sector within the range of the acquisition gate. After the button is released, the range gate will continue the limited search until lock-on to the first adequate target. With lock-on, target range, range rate, and position information are fed to the LCOSS and the radar antenna starts to conically scan about the target centroid, allowing the radar processor to extract steering information. A priority dogfight missile mode is also provided to permit the pilot to override other modes. With the dogfight switch on the stick actuated to the forward position, the range gate slews out on boresight to the limit of the 10-mile range scale. When the missile dogfight button is released, the radar will lock on to the first adequate target. If the radar was already locked on to a target, the lock-on will be maintained when the system is switched to either dogfight guns or

## IMPROVED FIRE CONTROL SYSTEM

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Guns Mode. The operation of the radar in the guns mode during acquisition and lock-on is identical to the operation of the basic APQ-153/APQ-157 radar except that after lock-on the radar will angle track the target throughout the gimbal limits of the flat plate antenna. This permits a reduced pilot workload by providing the pilot the capability of locking on to the target as it passes through boresight and keeping it "locked up" while maneuvering within the antenna gimbal limits. The guns mode is operated in dogfight guns only and transfer to dogfight missiles is accomplished without breaking lock-on. The resume-search button on the stick grip releases the system from this mode.

System Performance. The improvement in radar system performance is evident in several areas. The clutter environment is improved, providing a cleaner display for the pilot. This is due to the frequency agile transmitter, which can change transmitting frequency over a range of 100 MHz on a pulse-by-pulse basis, and the flat plate vertically polarized antenna. Together, they provide a 15 to 20 percent detection range improvement, a 5 db reduction in first sidelobes, and a 19 db reduction in the 90 degree sidelobes. These features effectively reduce STAE, "hat section" ground return interference, and altitude line interference and they minimize fade. The result is that the display sensitivity can be increased permitting improved target detection and a reduced pilot workload.

Off-boresight acquisition/angle track permits greater tactical flexibility. The pilot can acquire the target at any angle within the radar field of view, remain locked-on during target evasive maneuvers, and press for increased attack conversion intercepts.

A control stick dogfight missile/gun, resume-search switch permits the pilot to transfer from guns to missiles as the opportunity arises in a priority mode and to return to search without removing his hand from the stick grip.

Pipper slaving enhances the pilot's ability to see the target by aiming the LCOSS pipper to the target as determined by the radar azimuth and elevation coordinates.

### Modifications to the Line Replaceable Units

The improved radar line replaceable units (LRU) increase the total weight of the basic radar by about 10 pounds but have the same physical/installation dimensions.

The improved antenna assembly has a new support gimbal, azimuth and elevation rate gyros, flat plate antenna, extended frame mounting to accommodate the flat plate antenna, added section of wave guide, modified pressurization within one atmosphere absolute, and wiring changes for the tracking loop. The antenna for the improved radar is a vertically polarized, flat plate, phased array which replaces the center feed, horizontally polarized, parabolic antenna in the basic APQ-153/APQ-157 system. The flat plate antenna has about 3 db more main lobe gain, with a reduction in sidelobes noted previously. The need for radar attenuating material in the bottom of the radome is eliminated.

The modified radar set control has an added target designation pressure sensor for positioning the acquisition symbols on the radar display and range switching to provide a 40-mile range scale capability.

The transmitter/receiver unit has been equipped with a frequency agile magnetron and the associated local oscillator/receiver circuitry to follow the magnetron tuning. The magnetron has an agile bandwidth of 100 MHz on a pulse-by-pulse basis with an agile rate of 100 Hz and a peak power of 65 KW minimum.

The processor has been modified to incorporate the angle tracking loops, symbol generation, and circuitry for the target acquisition off-boresight and angle tracking, and the missile and gun dogfight switching logic.

The indicator for the improved radar is the same as the basic radar except for addition of the 40-mile range scale indication on the front bezel.

### Provisions for Added Capability

The improved radar may be converted for use with electro-optical systems by the addition of a cathode ray display tube and a digital scan converter. All circuitry and external plugs necessary for this conversion are included. This will provide dual mode video/radar display capability for use with video-guided weapons such as the AGM-65 Maverick. The required Maverick controller is incorporated in the radar set control. Circuitry is also provided for radar warning receiver (RWR) blanking should this equipment be installed.

# APPENDIX B

# F-5E TROPICAL ATMOSPHERE PERFORMANCE

# APPENDIX B

## F-5E TROPICAL ATMOSPHERE PERFORMANCE

F-5E performance values presented in this appendix are computed on the same basis as those presented in Section 2 with one exception. The major portion of Section 2 performance is computed for standard atmosphere. Performance herein is computed for MIL-STD-210A Tropical Atmosphere. The sea level temperature is 32.1°C (89.8°F) and the temperature lapse rate is presented in Figure B-1 below.

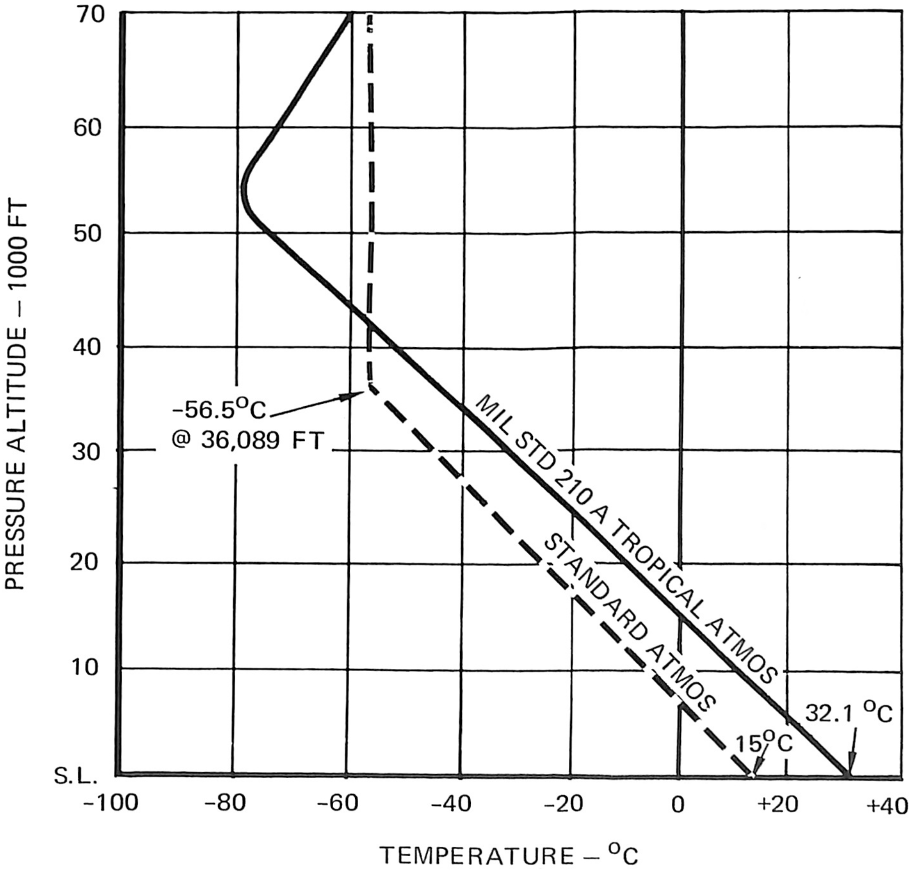


FIGURE B-1. TEMPERATURE – ALTITUDE COMPARISON

All performance in Appendix B pertains to the F-5E with JP-4 fuel except for the ferry missions, full ammunition. A Tropical Atmosphere/Standard Atmosphere Performance Comparison is presented in Table B-1. Weights are shown on Table 2-7 in Section 2.

## TABLE B-1. TROPICAL ATMOSPHERE PERFORMANCE COMPARISON (LAUNCHER RAIL CONFIGURATION)

| | TROP. ATMOS. | STAN. ATMOS. |
|---|---|---|
| TAKEOFF GROSS WEIGHT – POUNDS | 15,292 | 15,292 |
| TAKEOFF DISTANCE (SEA LEVEL) – FEET | 2,300 | 1,800 |
| TAKEOFF SPEED (SEA LEVEL) – KTAS | 144 | 144 |
| TIME TO CLIMB (BRAKE RELEASE TO 40,000 FEET) – MINUTES | 3.7 | 3.3 |
| RATE OF CLIMB (SEA LEVEL) – FEET PER MINUTE | 25,500* | 33,500* |
| MAXIMUM SPEED (36,089 FEET) – MACH NUMBER | 1.52* | 1.6* |
| MAXIMUM SPEED (SEA LEVEL) – MACH NUMBER | 0.99* | 1.02* |
| COMBAT CEILING – FEET | 52,800* | 52,500* |
| LANDING WEIGHT (LANDING FUEL RESERVES; AMMUNITION EXPENDED) – POUNDS | 11,192 | 11,192 |
| LANDING DISTANCE (WITH DRAG CHUTE SEA LEVEL) – FEET | 2,280 | 2,200 |
| LANDING SPEED (SEA LEVEL) – KTAS | 125 | 121 |

*WEIGHT: 13,092 POUNDS WITH 50 PERCENT FUEL AND LAUNCHER RAILS.

### TAKEOFF AND LANDING DISTANCES

Tropical Atmosphere takeoff ground distances and distances to clear a fifty-foot obstacle are presented for sea level takeoffs as a function of aircraft weight in Figure B-2. The takeoff ground-run varies from 2300 feet for the wingtip launcher rail configuration at 15,292 pounds, to 6400 feet at maximum-weight configuration at 24,018 pounds. The distance increases to 7150 feet for the maximum-weight growth configuration with AIM-9 missiles at 25,124 pounds.

Tropical Atmosphere landing distances for sea level are presented in Figure B-3 both with the drag chute and without the drag chute. The landing ground roll with drag chute and maximum braking (friction coefficient 0.300) is 2280 feet for the intercept mission landing weight of 11, 192 pounds.

### CLIMB AND MACH SUMMARIES

The Tropical Atmosphere climb capability of the F-5E aircraft, equipped with AIM-9 wingtip missiles and with launcher rails only, is presented in Figure B-4. The time-to-climb curve is calculated for an airplane weight that is reduced as fuel is used from the start of takeoff and time begins at brake release. The rate-of-climb curve is computed for a constant 50 percent fuel combat weight with 560 rounds of ammunition.

Maximum and military power Tropical Atmosphere level flight operational envelopes for the AIM-9 missile configuration and the launcher-rail-only configuration, both at 50 percent fuel combat weight with 560 rounds of ammunition are presented in Figure B-5.

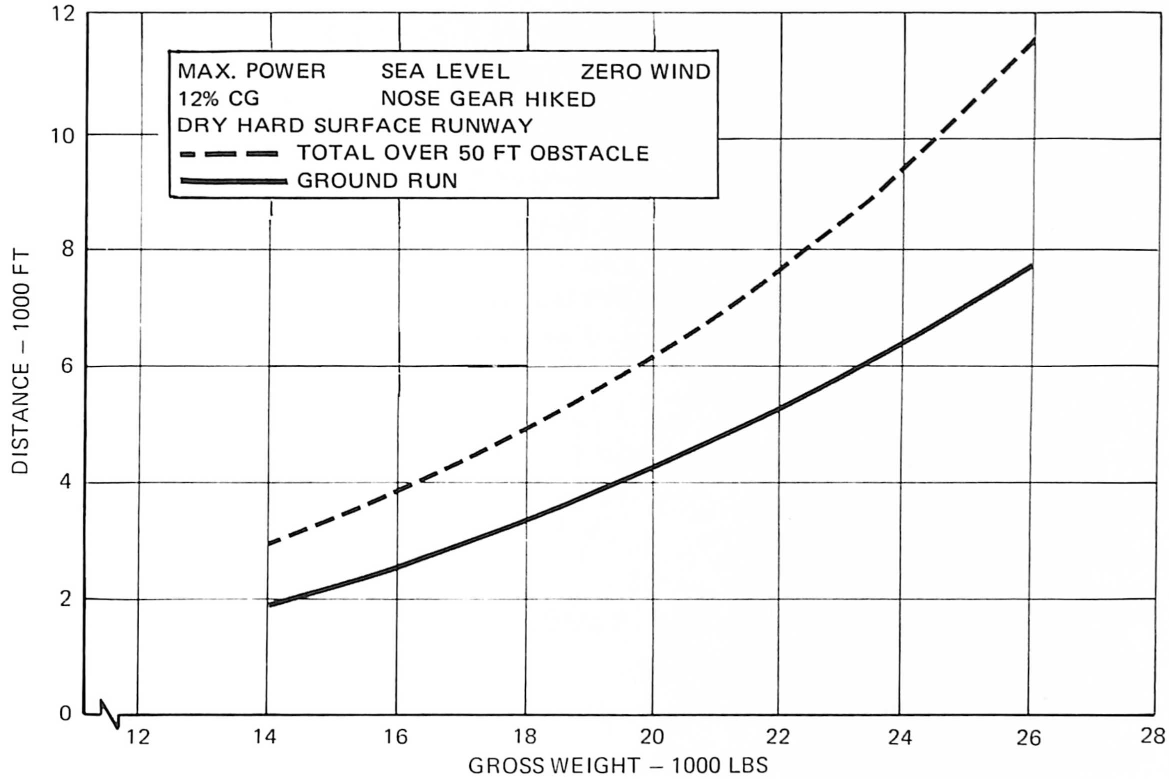


FIGURE B-2. F-5E TROPICAL ATMOSPHERE TAKEOFF DISTANCE

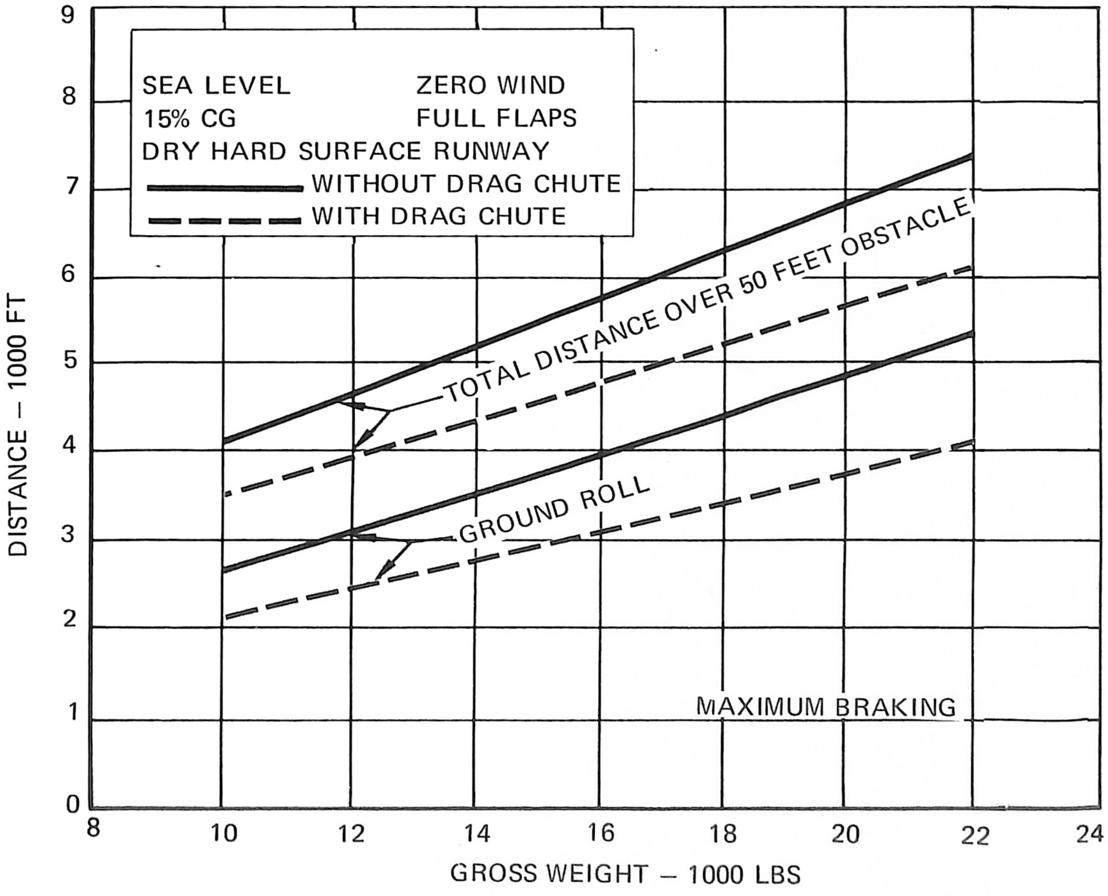


FIGURE B-3. F-5E TROPICAL ATMOSPHERE LANDING PERFORMANCE

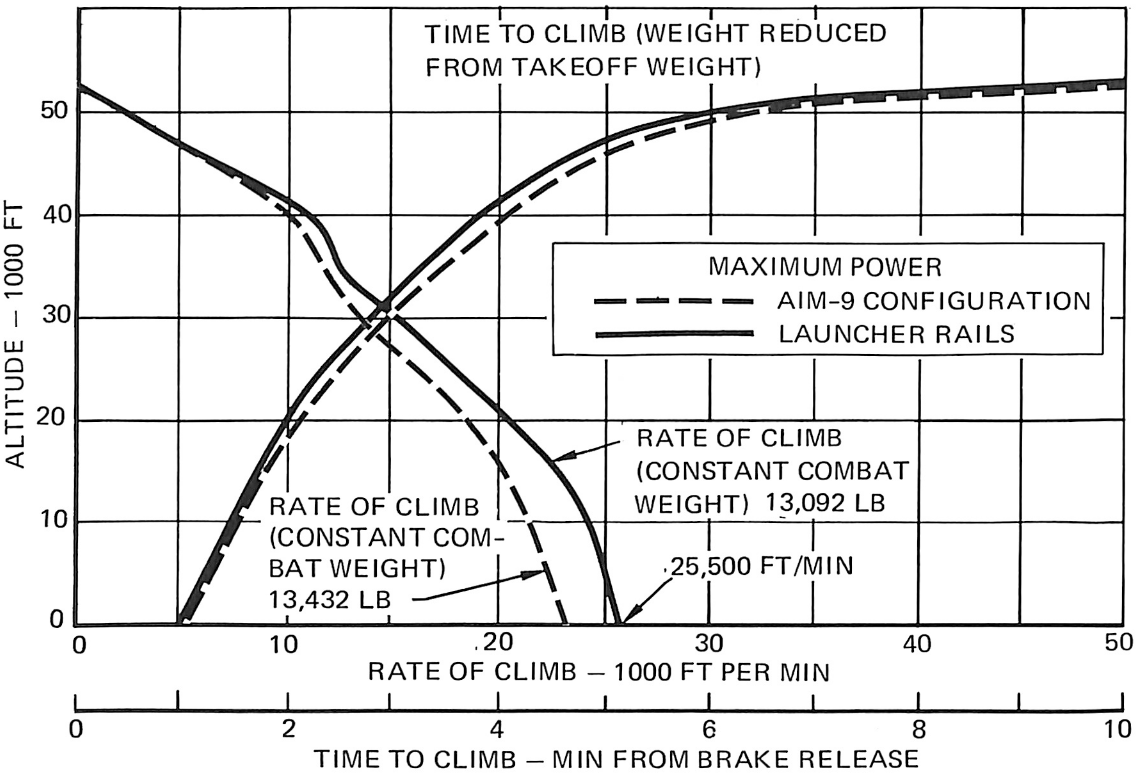


FIGURE B-4. F-5E TROPICAL ATMOSPHERE CLIMB PERFORMANCE

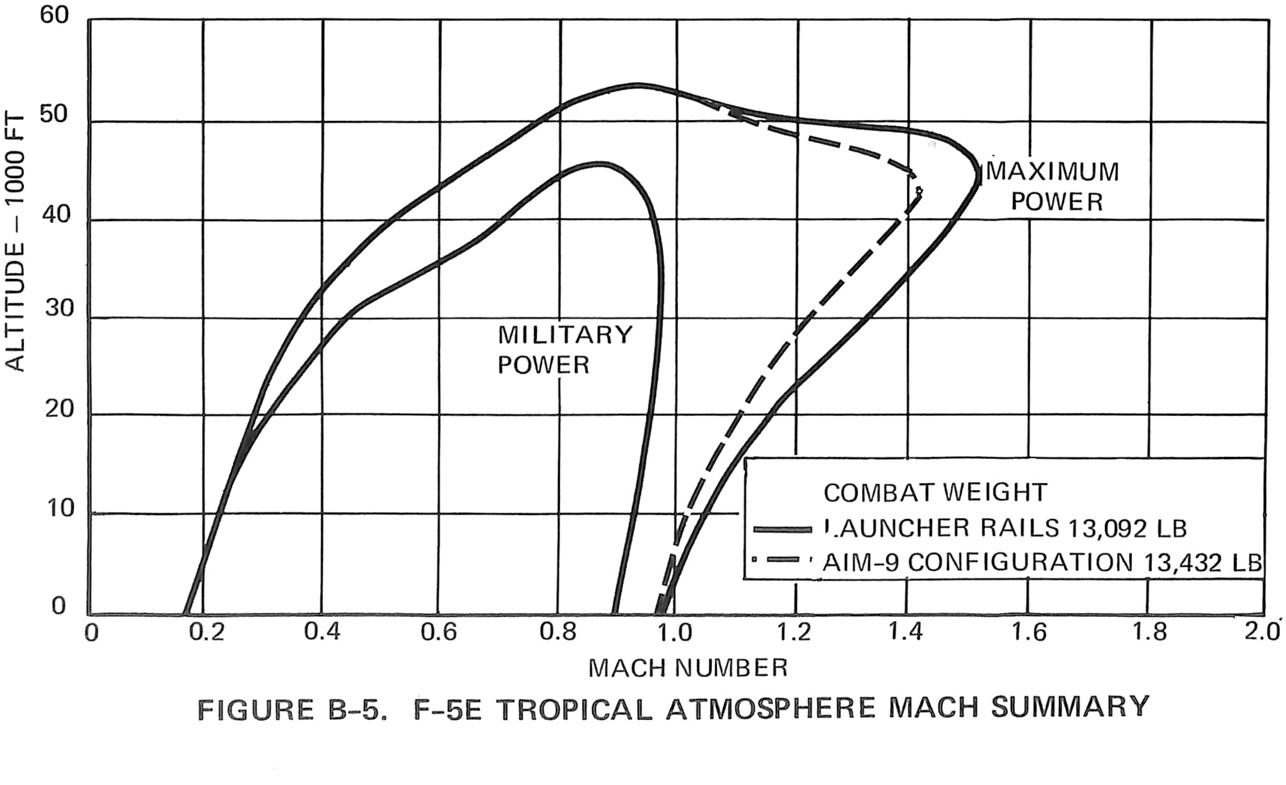


FIGURE B-5. F-5E TROPICAL ATMOSPHERE MACH SUMMARY

## MISSION PERFORMANCE

Data presented in the Tropical Atmosphere mission performance summary, Table B-2, were computed using the mission rules presented in each of the mission profile illustrations, Figures B-6 thru B-16, and the ferry mission rules on Figure B-17. Standard atmosphere mission performance is presented for comparison.

The mission rules do not allow a distance credit for letdown from cruise altitude. If allowance were given for letdown, approximately 20 nautical miles for LO-LO-HI and 40 nautical miles for HI-LO-HI could be added to the mission radii.

The F-5E carries 275-gallon tanks on the centerline and inboard wing pylons. Performance data with one (1), two (2) and three (3) pylon tanks are included herein. Missions and performance for multiple store loadings on Multiple Ejection Racks (MERs) and Triple Ejection Racks (TERs) are also presented. TER rack data show F-5E growth capability. See Figure 4-86 in the Armament Subsection of Section 4. for qualified stores and growth stores. The terms growth and growth capability are defined to mean those stores for which the airplane has complete provisions, hard points, racks, wiring, plumbing, etc., but which require clearance based on flight test qualification.

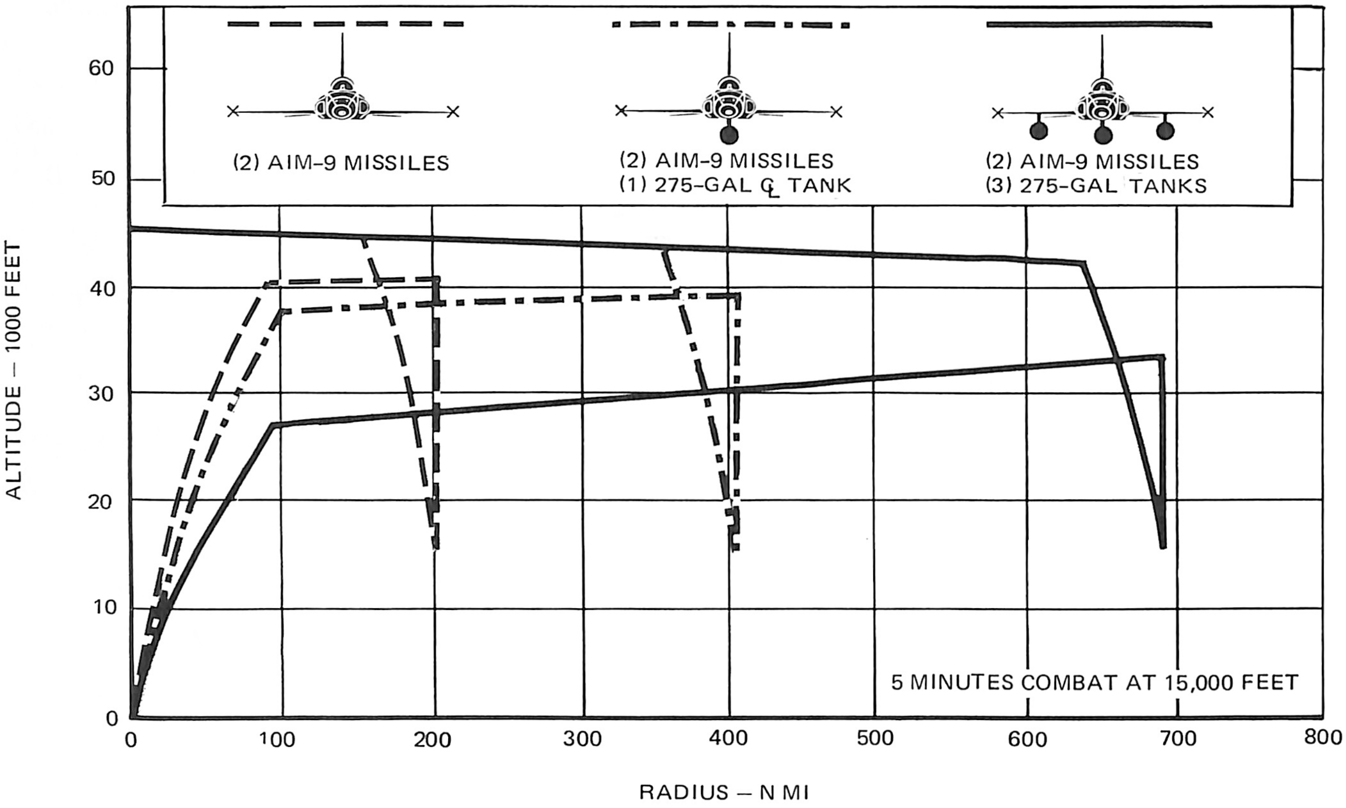
TABLE B-2. F-5E TROPICAL ATMOSPHERE MISSION PERFORMANCE COMPARISON

| MISSION | | TROP. ATMOS. | STAN. ATMOS. |
|---|---|---|---|
| COMBAT AIR PATROL (2) AIM-9 MISSILES | | | |
| (1) 275-GAL PYLON TANK | RADIUS | 410 N MI | 415 N MI |
| (3) 275-GAL PYLON TANKS | RADIUS | 690 N MI | 680 N MI |
| SUPERSONIC AREA INTERCEPT WITH 275-GAL ℄ TANK | RADIUS | 200 N MI | 190 N MI |
| POINT INTERCEPT (WITH (2) AIM-9'S) – TIME TO 40,000 FEET FROM BRAKE RELEASE | TIME | 4.1 MINUTES | 3.5 MINUTES |
| INTERDICTION (HI-LO-HI) | | | |
| (3) 275-GAL PYLON TANKS RETAINED | RADIUS | 520 N MI | 540 N MI |
| INTERDICTION (LO-LO-HI)* | | | |
| (3) 275-GAL PYLON TANKS RETAINED | RADIUS | 455 N MI | 460 N MI |
| INTERDICTION (LO-LO-LO)* | | | |
| MAXIMUM FUEL WITH (3) 275-GAL PYLON TANKS RETAINED | RADIUS | 380 N MI | 380 N MI |
| MAXIMUM BOMB LOAD | RADIUS | 150 N MI | 150 N MI |
| MAXIMUM BOMB LOAD (MER & TER RACKS, GROWTH) | RADIUS | 100 N MI | 100 N MI |
| FERRY WITH LAUNCHER RAILS | | | |
| 275-GAL ℄ PYLON TANK DROPPED | RANGE | 1365 N MI | 1395 N MI |
| 275-GAL ℄ PYLON TANK RETAINED | RANGE | 1285 N MI | 1315 N MI |
| FERRY WITH AIM-9 MISSILES | | | |
| (3) 275-GAL PYLON TANKS DROPPED | RANGE | 1715 N MI | 1755 N MI |
| (3) 275-GAL PYLON TANKS RETAINED | RANGE | 1515 N MI | 1555 N MI |

*LOW ALTITUDE CRUISE ON LO-LO-LO AND LO-LO-HI MISSIONS AT SEA LEVEL; COMBAT IS ALSO AT SEA LEVEL

## Combat Air Patrol Missions

Figure B-6 presents typical Tropical Atmosphere combat air patrol mission profiles with the mission rules applicable for the extended radius mission.



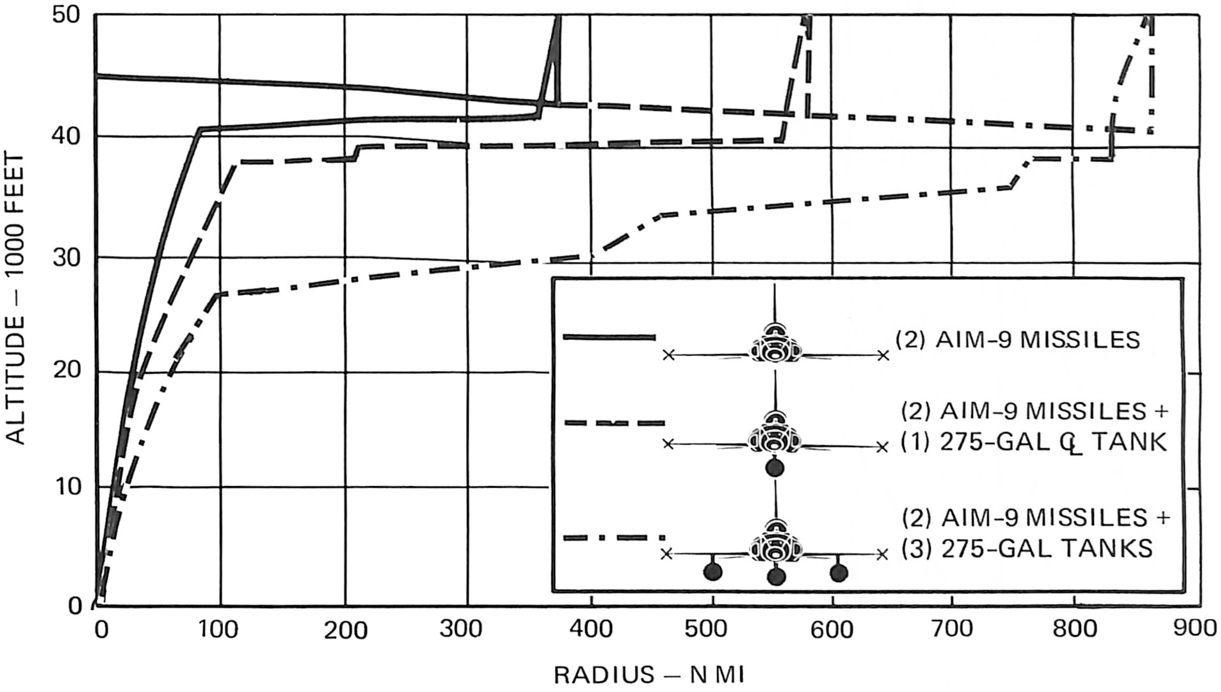
MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT
2 MILITARY POWER CLIMB
3 OPTIMUM CRUISE AT CRUISE ALTITUDE NOTED
4 LOITER AT CRUISE ALTITUDE
5 DESCENT OR CLIMB TO COMBAT ALTITUDE. NO FUEL, TIME OR DISTANCE CREDIT
6 DROP TANKS AND PYLONS AT START OF COMBAT
7 COMBAT: MAXIMUM POWER AT 15,000 FEET AT 0.80 MACH NUMBER, FIRE MISSILES AND AMMO
8 MILITARY POWER CLIMB TO CRUISE ALTITUDE ABOVE 15,000 FEET OR MAXIMUM RANGE DESCENT TO CRUISE ALTITUDES BELOW 15,000 FEET
9 OPTIMUM CRUISE AT CRUISE ALTITUDE
10 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT
11 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

FIGURE B-6. F-5E TROPICAL ATMOSPHERE COMBAT AIR PATROL MISSIONS

### Subsonic Area Intercept Mission

Figure B-7 presents the F-5E Tropical Atmosphere air-to-air subsonic high altitude area intercept capabilities when operating at normal cruise speeds. Missions are shown with AIM-9 missiles only and with one and three pylon tanks. Wing tanks are dropped when empty. Centerline tank and all pylons are dropped when the centerline tank is empty.



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KIAS, THEN MILITARY POWER ACCELERATION TO CLIMB SPEED. NO DISTANCE CREDIT

2 MILITARY POWER CLIMB

3 DROP WING PYLON FUEL TANKS WHEN EMPTY

4 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

5 DROP CENTERLINE FUEL TANK AND ALL PYLONS WHEN ℄ TANK IS EMPTY

6 MAXIMUM POWER CLIMB TO 50,000 FEET OR COMBAT CEILING WHICHEVER IS LOWER

7 COMBAT: 5 MINUTES AT COMBAT CEILING OR 50,000 FEET, WHICHEVER IS LOWER, FIRE MISSILES AND AMMO

8 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

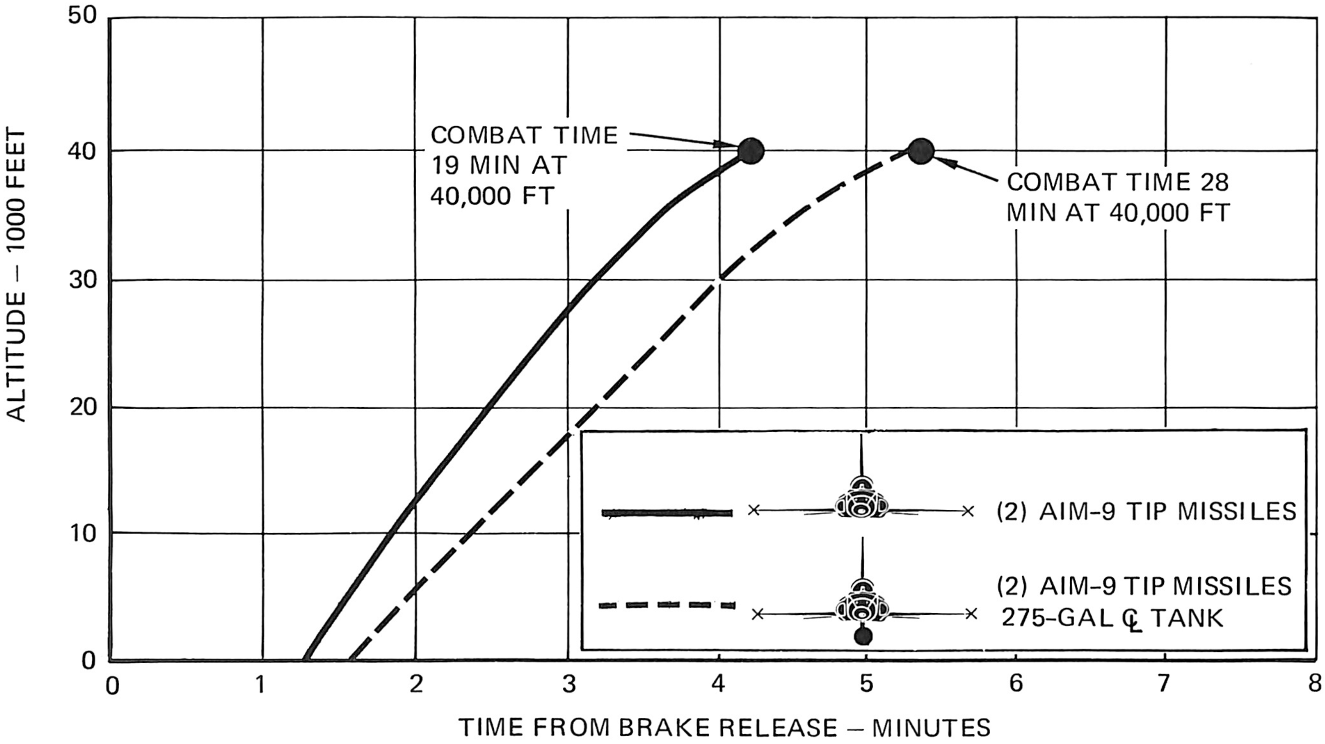
9 DESCENT: NO FUEL, TIME OR DISTANCE CREDIT

10 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

FIGURE B-7. F-5E TROPICAL ATMOSPHERE SUBSONIC AREA INTERCEPT MISSIONS

### Subsonic Point Intercept Mission

The minimum Tropical Atmosphere subsonic point intercept time, along with combat time duration on station at 40,000 feet, is shown in Figure B-8, for the missiles-only and the missiles-plus-centerline-tank configurations.



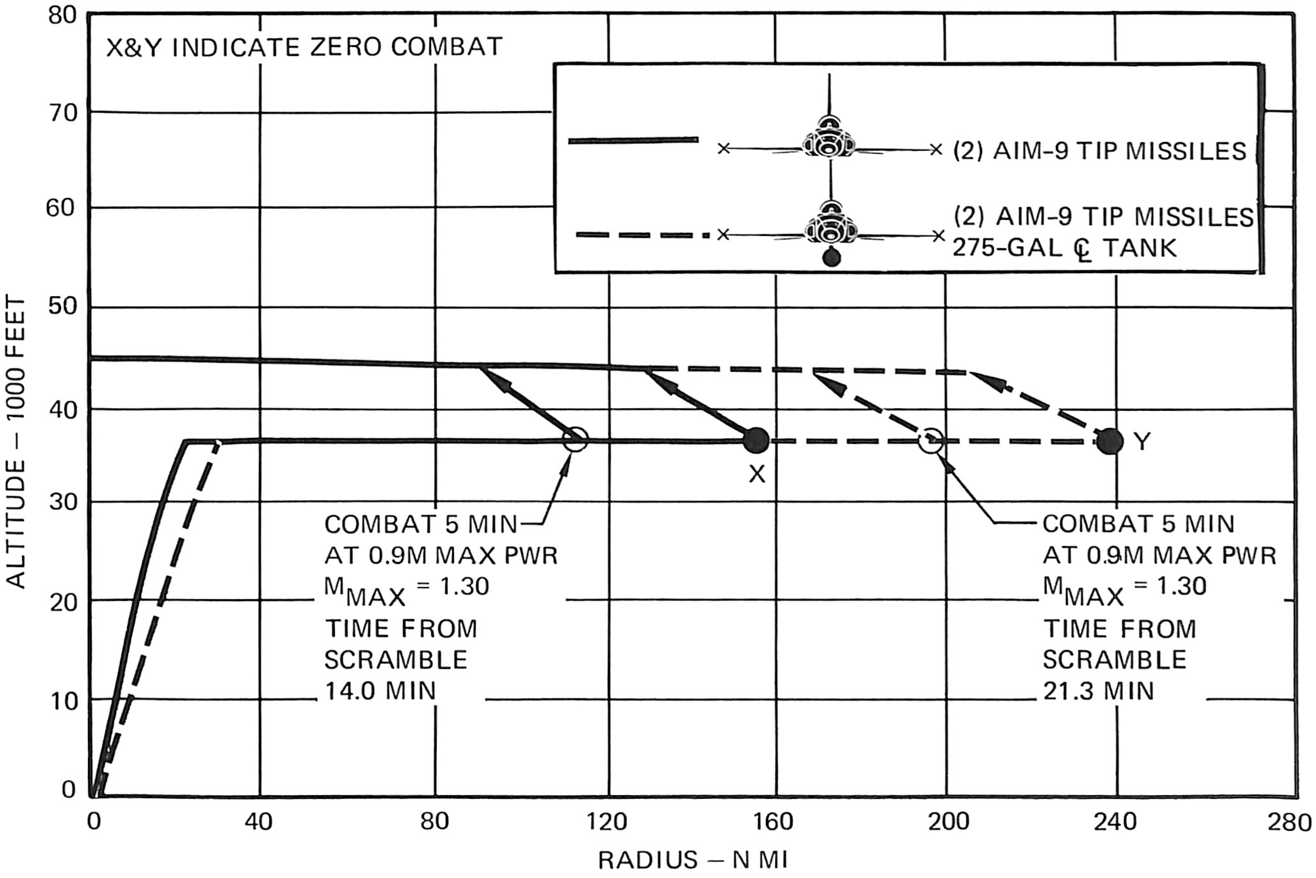
MISSION RULES

1. TAKEOFF ALLOWANCES: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO CLIMB SPEED, NO DISTANCE CREDIT
2. MAXIMUM POWER CLIMB TO 40,000 FEET
3. COMBAT AT MAXIMUM POWER, FIRE AMMO AND MISSILES
4. LANDING RESERVE: FUEL FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL
5. DROP ℄ TANK AND PYLON AT START OF COMBAT

FIGURE B-8. F-5E TROPICAL ATMOSPHERE SUBSONIC POINT INTERCEPT MISSIONS

## Supersonic Intercept Mission

Typical Tropical Atmosphere supersonic intercept mission profiles are presented in Figure B-9 for the missiles-only and missiles-plus-centerline-tank configurations. Profiles are presented for five minutes combat and also for zero combat time.



MISSION RULES

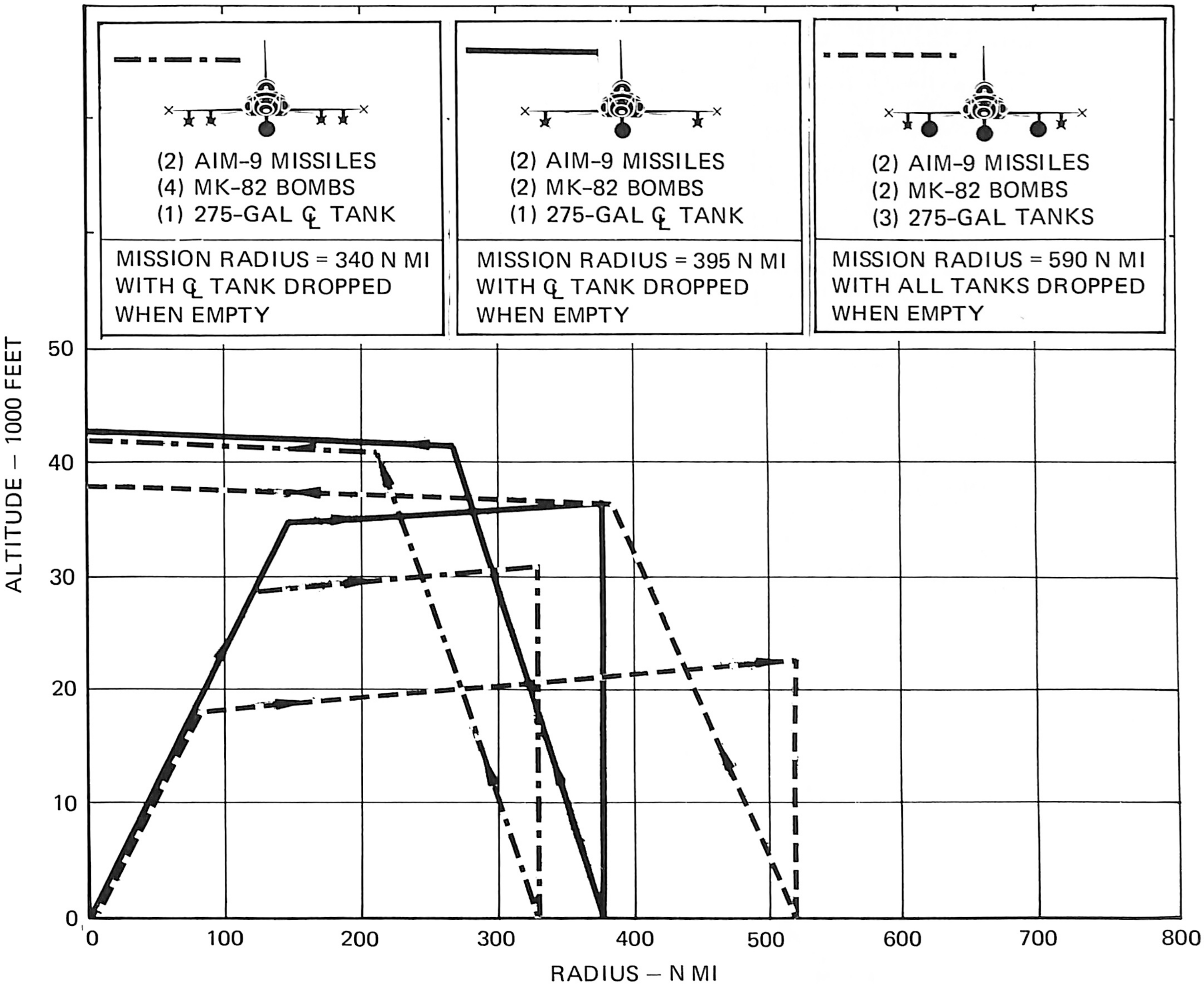
1. TIME FOR SCRAMBLE 2.6 MINUTES
2. TAKEOFF ALLOWANCES: FUEL USED FOR 5 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATION TO CLIMB SPEED. NO DISTANCE CREDIT
3. MAXIMUM POWER CLIMB TO ALTITUDE
4. MAXIMUM POWER ACCELERATION TO $V_{MAX}$
5. DROP TANK AND PYLON WHEN TANK IS EMPTY
6. COMBAT: MAXIMUM POWER, FIRE MISSILES AND AMMO
7. MILITARY POWER CLIMB TO OPTIMUM CRUISE ALTITUDE
8. OPTIMUM CRUISE
9. DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT
10. LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

FIGURE B-9. F-5E TROPICAL ATMOSPHERE SUPERSONIC INTERCEPT MISSIONS

## Interdiction Missions

The interdiction missions demonstrate the ability of the F-5E to deliver a given payload over long distances where no loiter is required at the target. HI-LO-HI missions are used when optimum cruise is required both to and from the target to obtain maximum radius. The low-altitude (sea level) optimum cruise outbound is used to minimize airplane detection prior to bomb drop (LO-LO-HI profile). The mission return is at high altitude optimum cruise. Sea level cruise, both to and from the target, is demonstrated by the LO-LO-LO profiles. These missions are flown when minimum aircraft detection is desired both to and from the target area. Typical Tropical Atmosphere mission profiles are shown in Figures B-10 through B-13. Note that the LO-LO-LO radii, Figures B-12 and B-13, are the same as the standard day values.

Mission time as a function of Tropical Atmosphere interdiction mission radius for various MK-82 bomb loadings for the HI-LO-HI profile is shown in Figure B-14. The 20-minute sea level loiter landing reserve time is not included in the total mission time.



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS. THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT

2 MILITARY POWER CLIMB

3 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

4 DESCENT: TO SEA LEVEL, NO FUEL, TIME OR DISTANCE CREDIT

5 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO. MISSILES RETAINED

6 MILITARY POWER CLIMB

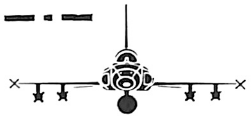
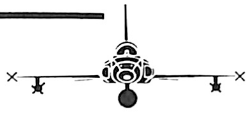
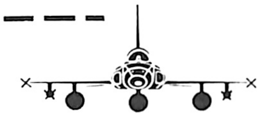
7 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

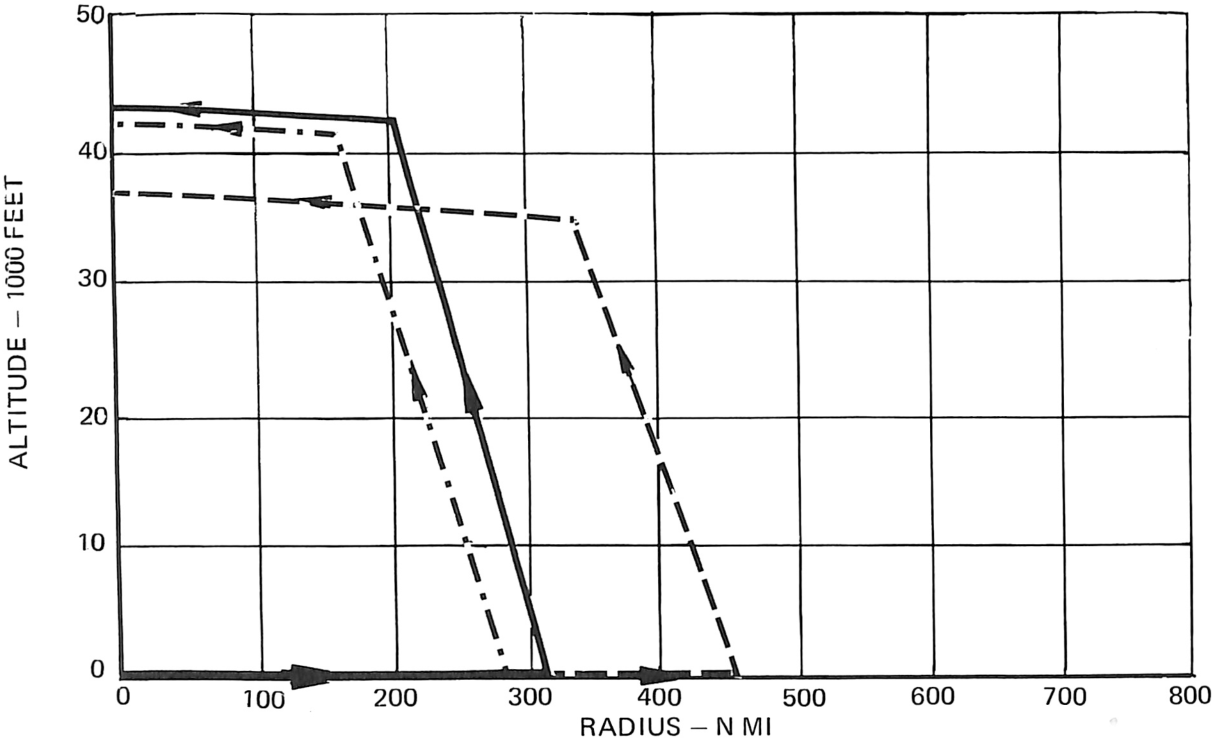
8 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT

9 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

10 TANKS AND PYLONS RETAINED

FIGURE B-10. F-5E TROPICAL ATMOSPHERE INTERDICTION MISSION (HI-LO-HI)

| — · — · — | ———— | — — — — |
|---|---|---|
| <br>(2) AIM-9 MISSILES<br>(4) MK-82 BOMBS<br>(1) 275-GAL ℄ TANK | <br>(2) AIM-9 MISSILES<br>(2) MK-82 BOMBS<br>(1) 275-GAL ℄ TANK | <br>(2) AIM-9 MISSILES<br>(2) MK-82 BOMBS<br>(3) 275-GAL TANKS |
| MISSION RADIUS = 295 N MI WITH ℄ TANK DROPPED WHEN EMPTY | MISSION RADIUS = 325 N MI WITH ℄ TANK DROPPED WHEN EMPTY | MISSION RADIUS = 510 N MI WITH ALL TANKS DROPPED WHEN EMPTY |



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS. THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT

2 OPTIMUM CRUISE AT SEA LEVEL

3 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO

4 MILITARY POWER CLIMB

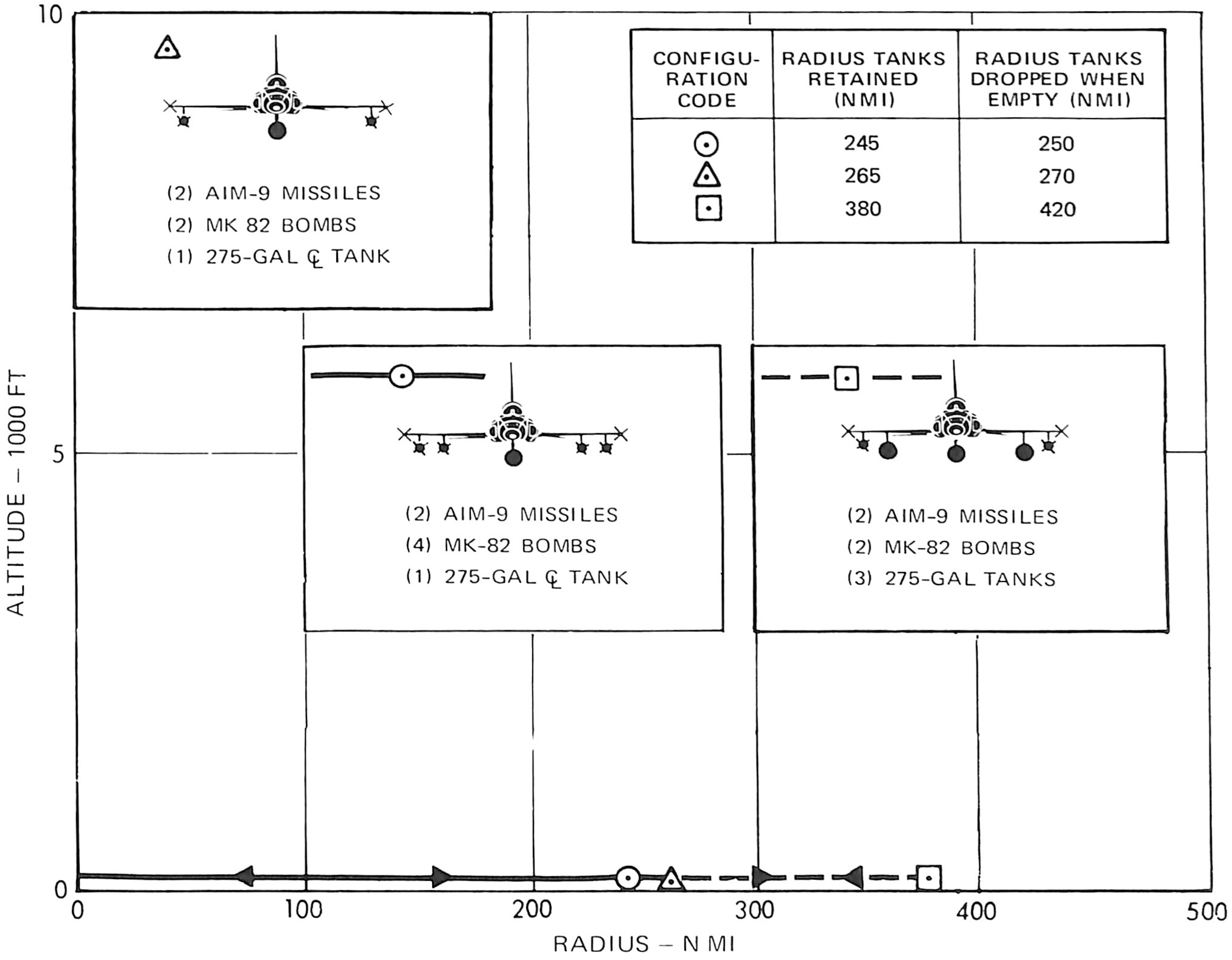
5 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

6 DESCENT: NO FUEL, TIME, OR DISTANCE CREDIT

7 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

8 TANKS AND PYLONS RETAINED

FIGURE B-11. F-5E TROPICAL ATMOSPHERE INTERDICTION MISSION (LO-LO-HI)



| CONFIGURATION CODE | RADIUS TANKS RETAINED (NMI) | RADIUS TANKS DROPPED WHEN EMPTY (NMI) |
|---|---|---|
| ⊙ | 245 | 250 |
| △ | 265 | 270 |
| ⊡ | 380 | 420 |

MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM TAKEOFF AND ACCELERATE TO 300 KCAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT

2 OPTIMUM CRUISE AT SEA LEVEL

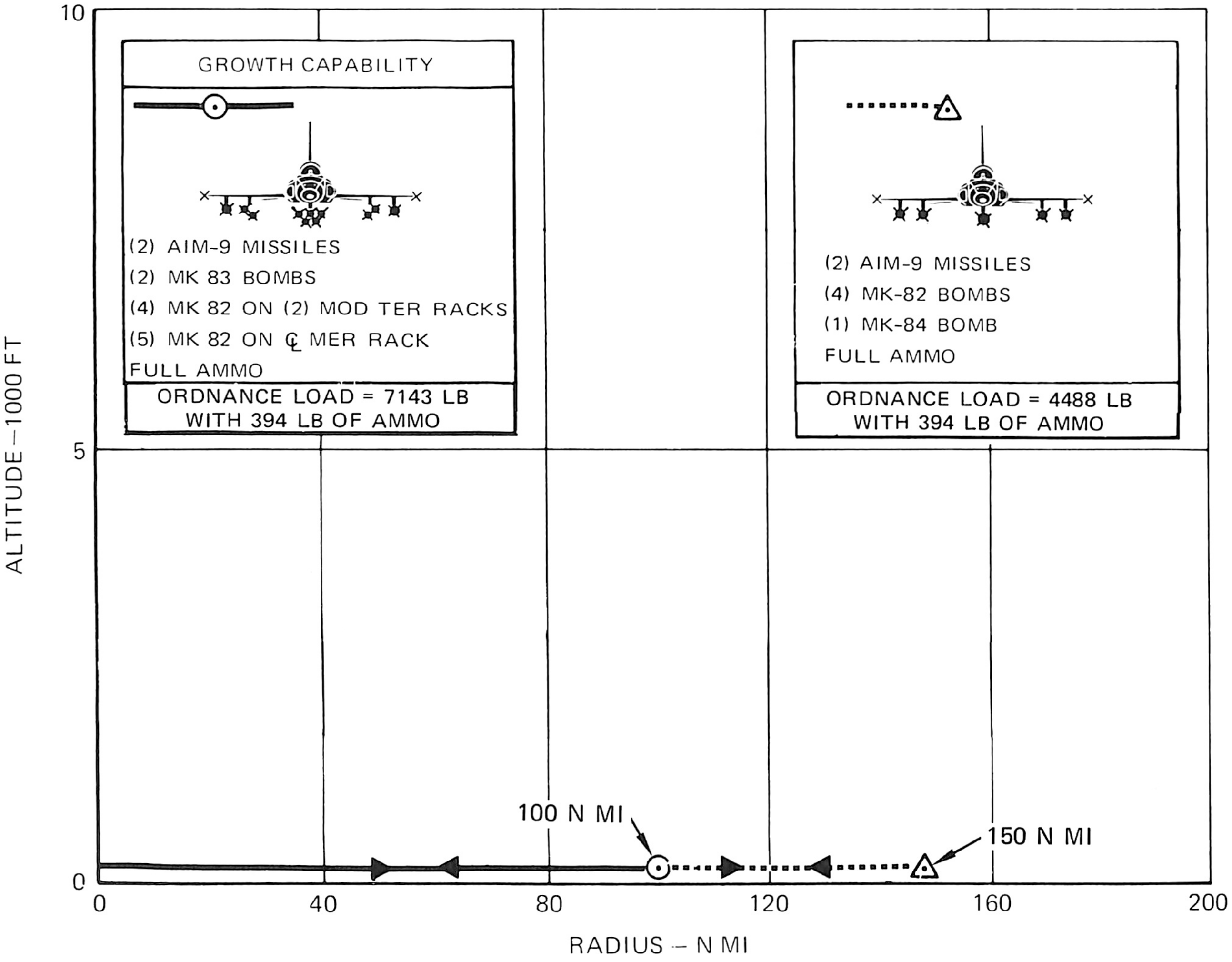
3 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO. MISSILES RETAINED

4 OPTIMUM CRUISE AT SEA LEVEL

5 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

6 TANKS AND PYLONS RETAINED

FIGURE B-12. F-5E TROPICAL ATMOSPHERE INTERDICTION MISSION (LO-LO-LO) MAXIMUM FUEL LOAD



MISSION RULES

1 TAKEOFF ALLOWANCES: FUEL USED FOR 10 MINUTES IDLE POWER. MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS. THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT

2 OPTIMUM CRUISE AT SEA LEVEL

3 COMBAT: 5 MINUTES AT MILITARY POWER AT SEA LEVEL AT 0.7 MACH NUMBER. DROP BOMBS AND FIRE AMMO. MISSILES RETAINED

4 OPTIMUM CRUISE AT SEA LEVEL

5 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

FIGURE B-13. F-5E TROPICAL ATMOSPHERE INTERDICTION MISSION (LO-LO-LO) (MAX BOMB LOAD)

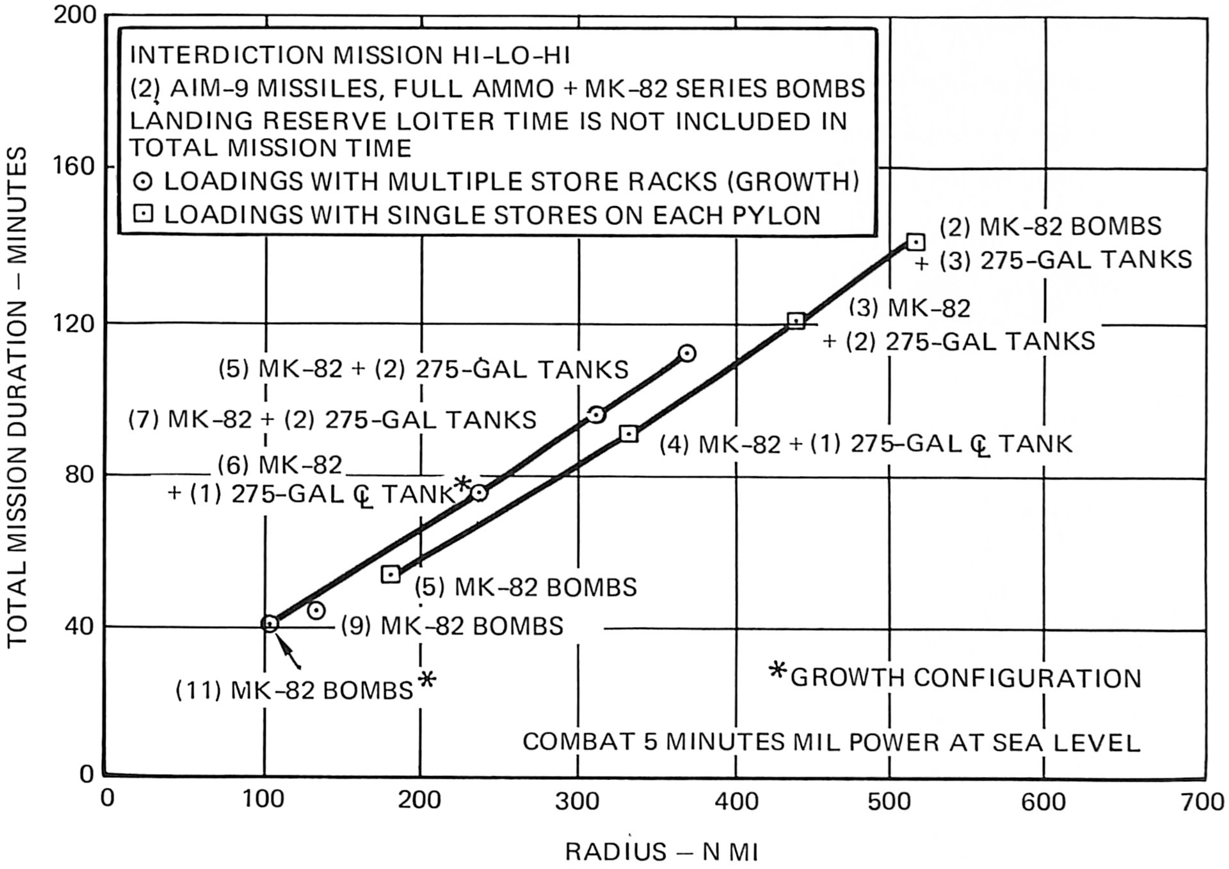


FIGURE B-14. F-5E TROPICAL ATMOSPHERE INTERDICTION MISSION DURATION VS COMBAT RADIUS (HI-LO-HI)

## Close Air Support Mission

Tropical Atmosphere combat radius as a function of close air support mission loiter time prior to combat is presented in Figure B-15. The figure presents loiter/radius capability for single MK-82, 500-pound-class bomb configurations. Figure B-16 shows the variation of total mission time with precombat loiter times for single MK-82 bombs for the Tropical Atmosphere close air support missions.

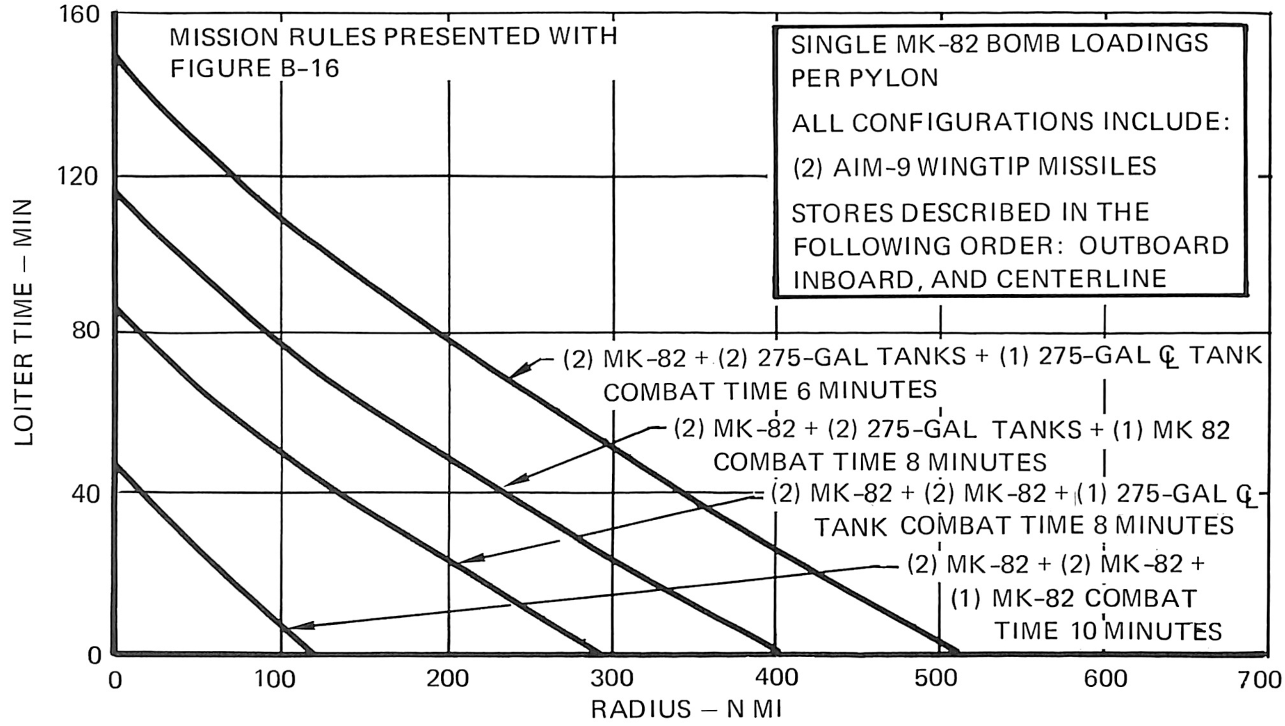
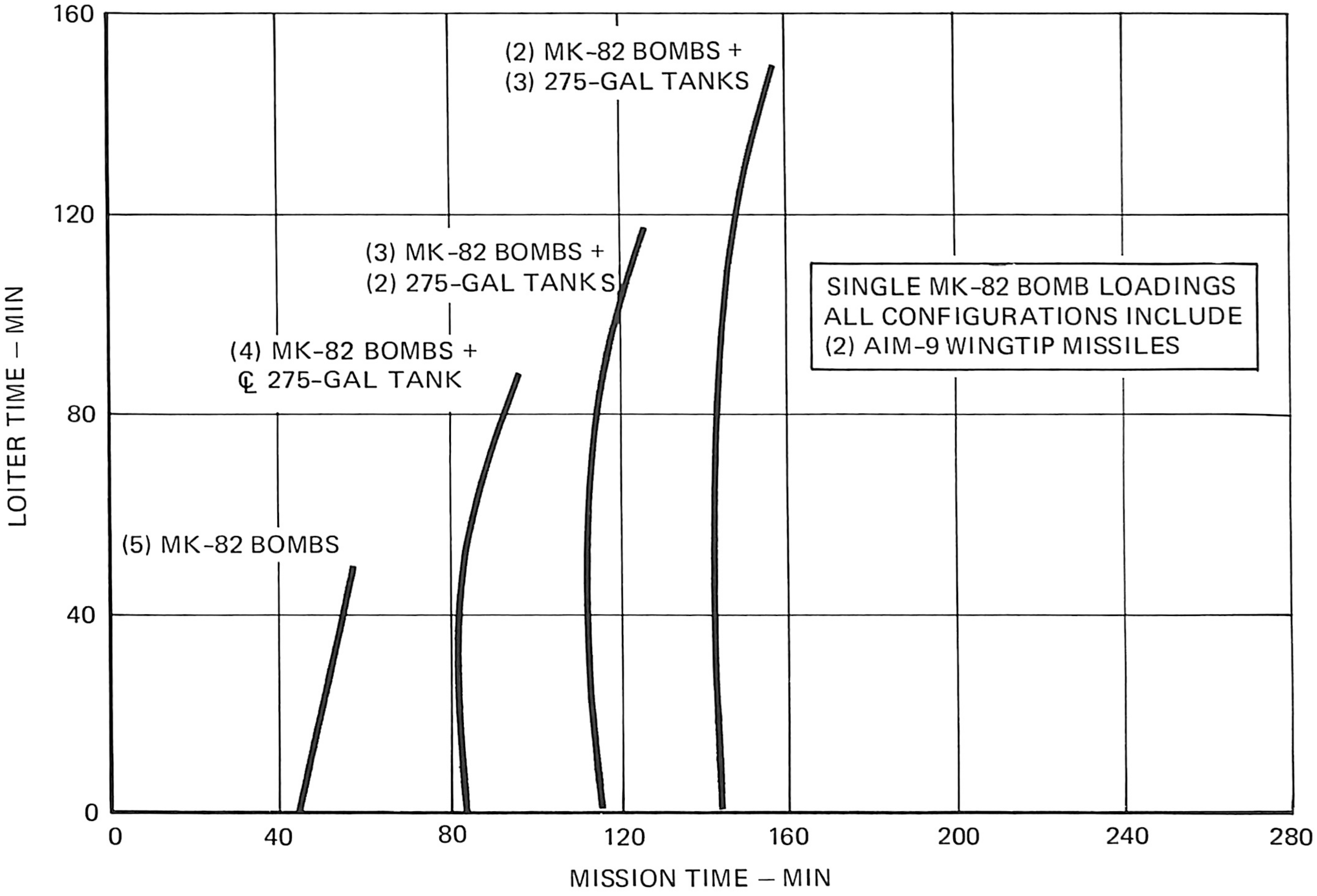


FIGURE B-15. F-5E TROPICAL ATMOSPHERE CLOSE AIR SUPPORT MISSION LOITER TIME VS COMBAT RADIUS SINGLE MK-82 BOMB LOADINGS PER PYLON



MISSION RULES

1 TAKEOFF ALLOWANCE: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KCAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT

2 MILITARY POWER CLIMB

3 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

4 LOITER: MAXIMUM ENDURANCE AT SEA LEVEL

5 COMBAT: MILITARY POWER COMBAT AT SEA LEVEL AT 0.7 MACH NUMBER IN ACCORDANCE WITH FOLLOWING TABLE WHICH INCLUDES 4 MINUTES FOR GUN FIRING PLUS TIME FOR AIR-TO-GROUND ORDNANCE DELIVERY

| NO. BOMBS | COMBAT TIME (MINUTES) |
|---|---|
| 1 OR 2 | 6 |
| 3 OR 4 | 8 |
| 5 OR 6 | 10 |

7 MILITARY POWER CLIMB

8 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE

9 DESCENT: TO SEA LEVEL, NO FUEL, TIME OR DISTANCE CREDIT

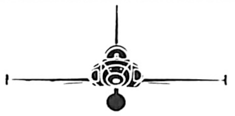
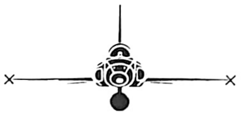
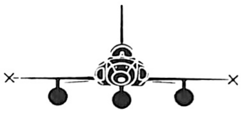
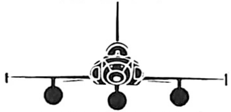
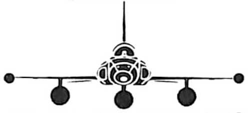
10 LANDING RESERVE: FUEL USED FOR 20 MINUTES MAXIMUM ENDURANCE SEA LEVEL

11 TANKS, PYLONS, AND MISSILES ARE RETAINED

FIGURE B-16. F-5E TROPICAL ATMOSPHERE CLOSE AIR SUPPORT LOITER TIME VS MISSION TIME (SINGLE MK-82 LOADINGS)

## Ferry Missions

The Tropical Atmosphere ferry missions shown in Figure B-17 demonstrate the maximum distances that the F-5E airplane can be flown between any two bases.

| CONFIGURATION | RANGE N MI | |
|---|---|---|
| | TANKS RETAINED | TANKS DROPPED |
|  LAUNCHER RAILS<br>(1) 275-GAL ℄ TANK | 1285 | 1365 |
|  (2) AIM-9 MISSILES<br>(1) 275-GAL ℄ TANK | 1195 | 1265 |
|  (2) AIM-9 MISSILES<br>(3) 275-GAL TANKS | 1515 | 1715 |
| (GROWTH)  LAUNCHER RAILS<br>(3) 275-GAL TANKS | 1600 | 1835 |
| (GROWTH)  (2) 50-GAL TIP TANKS<br>(3) 275-GAL TANKS | 1650 | 1890 |

MISSION RULES

1 TAKEOFF ALLOWANCE: FUEL USED FOR 10 MINUTES IDLE POWER, MAXIMUM POWER TAKEOFF AND ACCELERATE TO 300 KIAS, THEN ACCELERATE AT MILITARY POWER TO CLIMB SPEED. NO DISTANCE CREDIT

2 MILITARY POWER CLIMB

3 OPTIMUM CRUISE AT OPTIMUM CRUISE ALTITUDE FOR MISSION

4 DESCENT: NO FUEL TIME AND DISTANCE CREDIT

5 LANDING RESERVE: FUEL FOR 20 MINUTES MAXIMUM ENDURANCE AT SEA LEVEL

6 PYLONS RETAINED, TANKS AS NOTED

FIGURE B-17. F-5E TROPICAL ATMOSPHERE FERRY MISSIONS

## Combat Maneuvering Performance

The F-5E Tropical Atmosphere speed/altitude envelope is superimposed on the air battle arena in Figure B-18. The envelope fully encompasses the air battle arena. Although the maximum Mach number is reduced slightly from the standard atmosphere case, the altitude for $M_{max}$ is increased significantly.

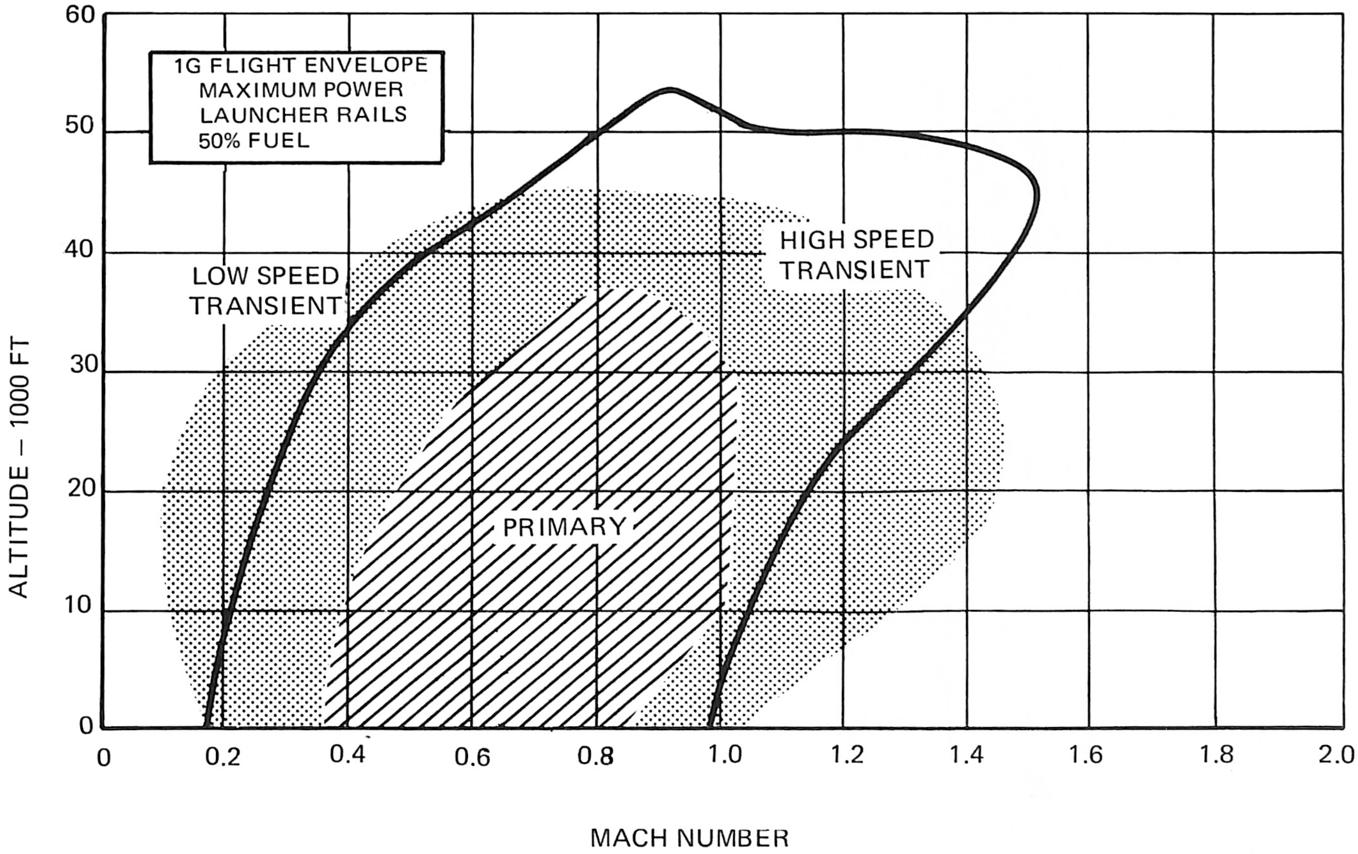


FIGURE B-18. F-5E MACH/ALTITUDE SUMMARY AND AIR BATTLE ARENA – TROPICAL ATMOSPHERE

The F-5E Tropical Atmosphere maneuvering performance is illustrated in Figures B-19, B-20 and B-21, for altitudes of 5,000, 15,000, and 30,000 feet, respectively. For example, Figure B-19 shows that at 5,000 feet and 0.6 Mach number the F-5E has a Tropical Atmosphere sustained turn rate of 11.8 degrees per second with a 3300-foot turn radius at a load factor of 4.4g. The maximum lift turn rate for the F-5E at 5,000 feet and 0.6 Mach number is 20.3 degrees per second and the turn radius is 1900 feet at the design limit load factor of 7.33g.

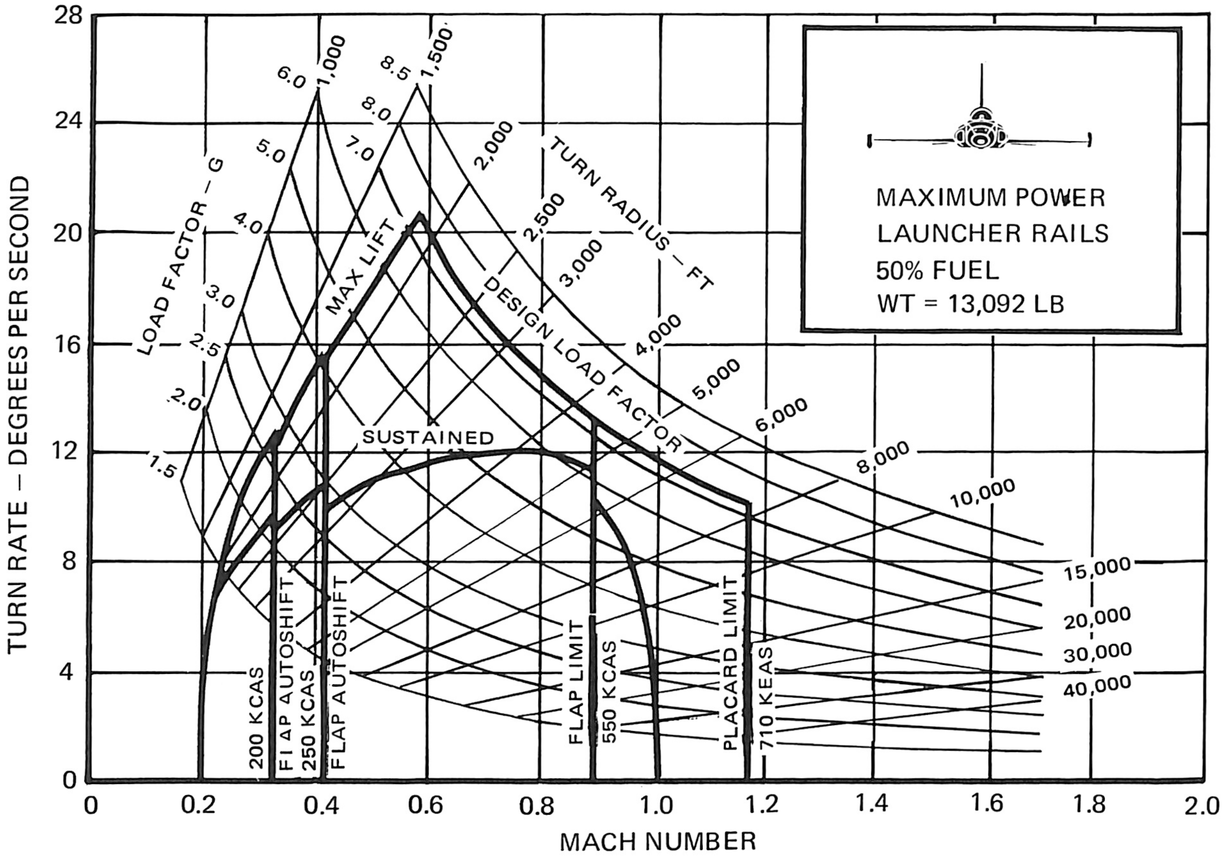


FIGURE B-19. F-5E TROPICAL ATMOSPHERE TURN PERFORMANCE – 5,000 FEET

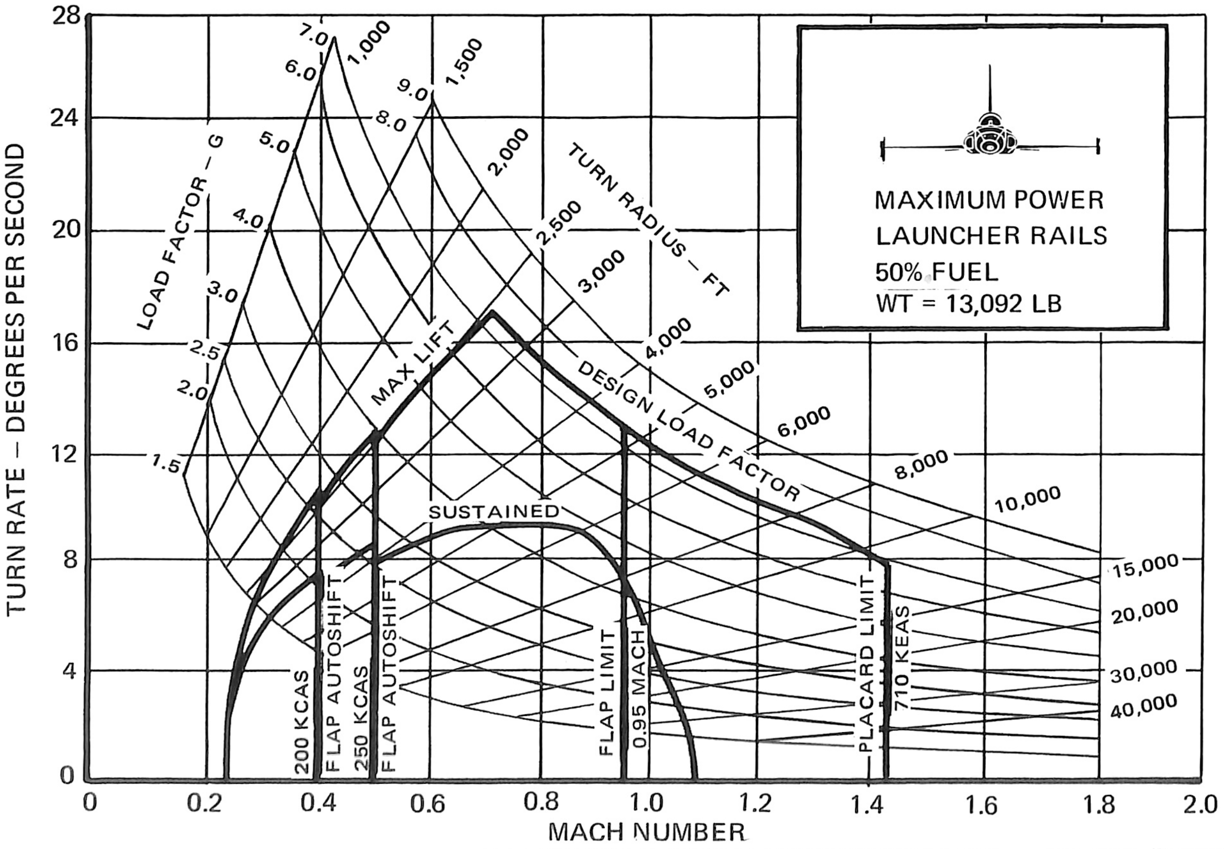


FIGURE B-20. F-5E TROPICAL ATMOSPHERE TURN PERFORMANCE – 15,000 FEET

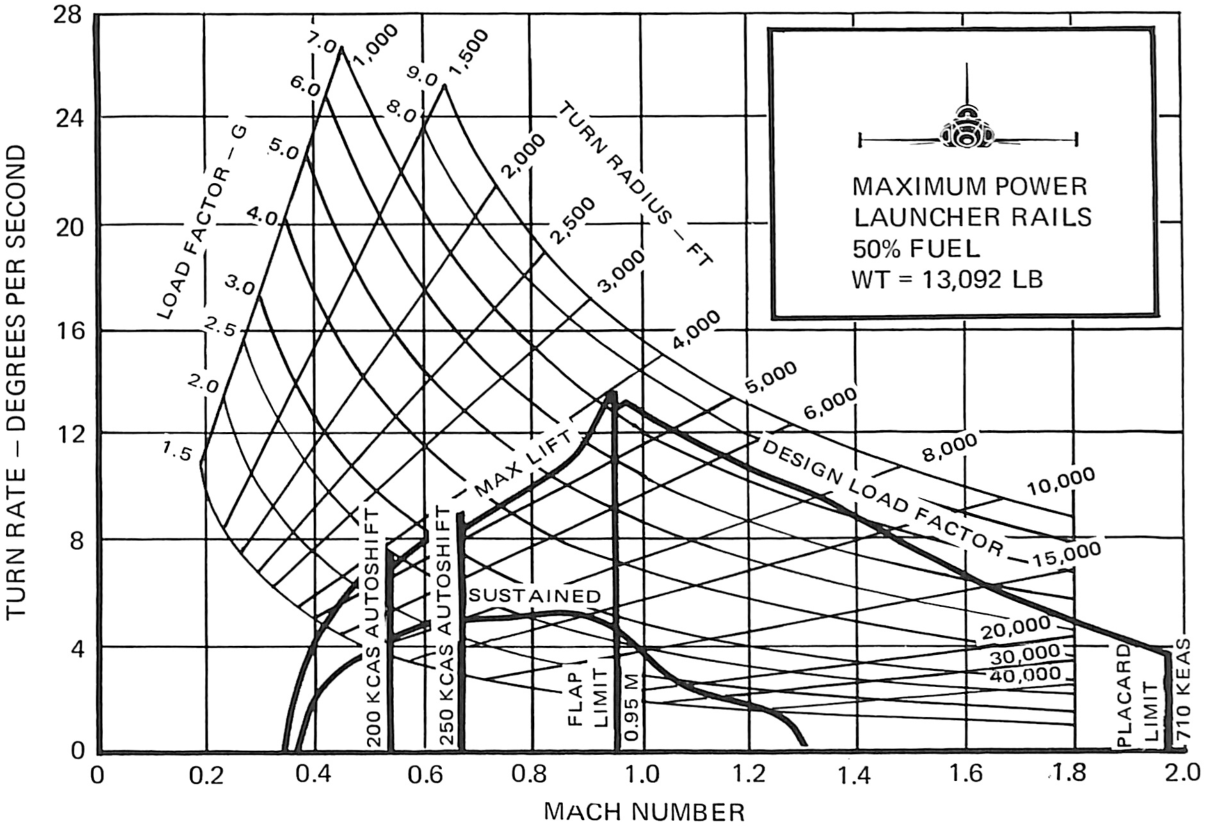


FIGURE B-21. F-5E TROPICAL ATMOSPHERE TURN PERFORMANCE – 30,000 FEET

Tropical Atmosphere Specific Power ($P_s$) versus Turn Rate data for the F-5E are plotted in Figures B-22 and B-23. The significance of $P_s$ was explained in Section 2.

## Single-Engine Performance

The F-5E Tropical Atmosphere single-engine maximum thrust climb capability is shown in Figure B-24 for typical takeoff loadings including both cleared and growth configurations. The rates of climb shown assume that flap and landing gear have been retracted, and that the aircraft is at its best single-engine climb speed. Figure B-25 illustrates the single-engine-performance capability of the aircraft without external stores for the same conditions. Figure B-26 shows that single-engine cruise can be maintained with only a slight decrease in nautical miles per pound of fuel (from the two-engine case) at low altitudes, and approximately a 20 percent reduction in miles per pound from dual-engine operation at the single-engine military power service ceiling. Single-engine partial-afterburner cruise in a Tropical Atmosphere can be maintained at altitudes to 36,000 feet.

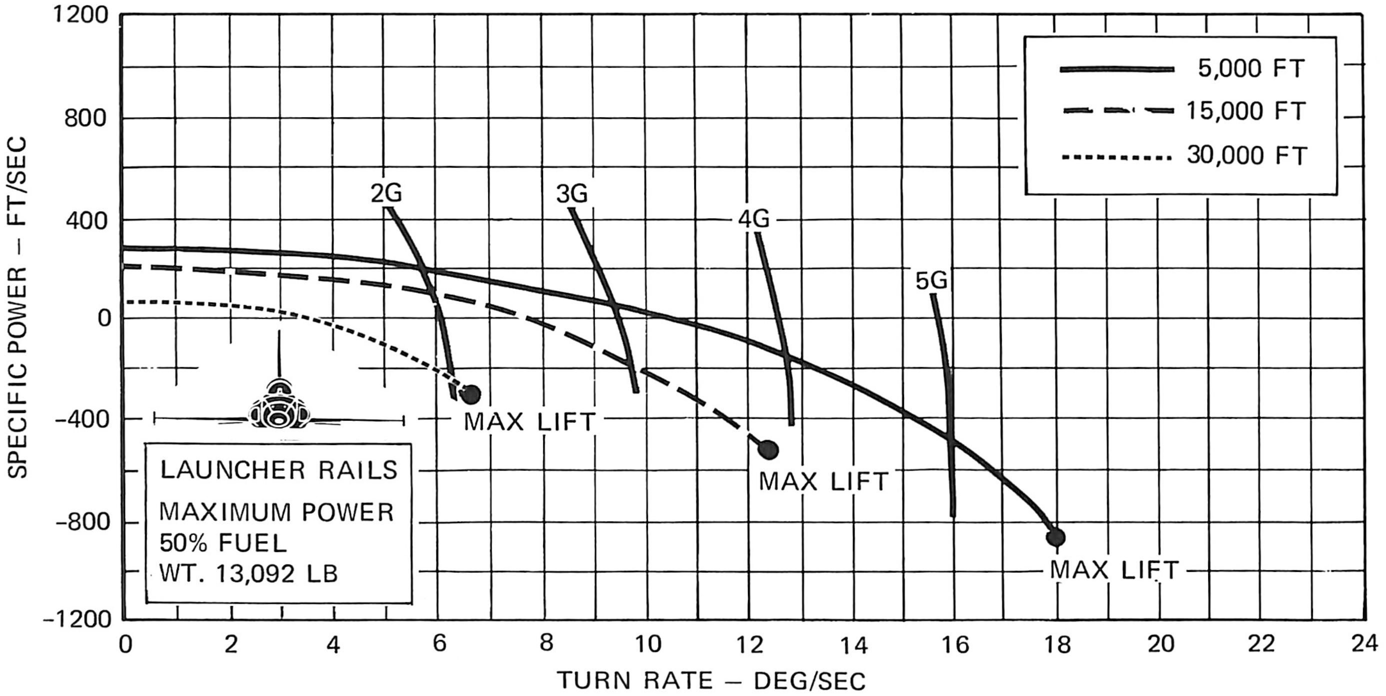


FIGURE B-22. F-5E TROPICAL ATMOSPHERE SPECIFIC POWER VS TURN RATE – MACH 0.5

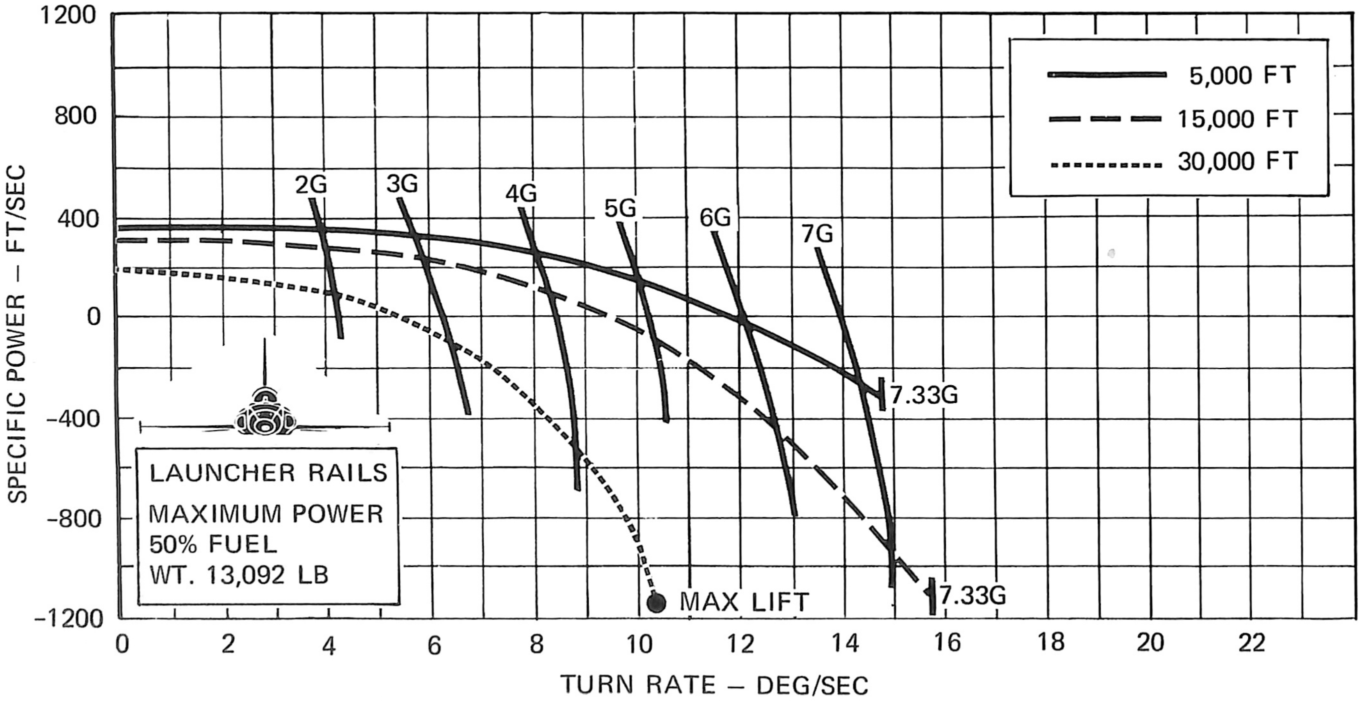
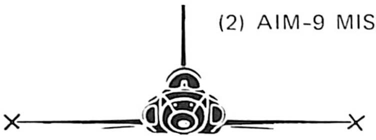
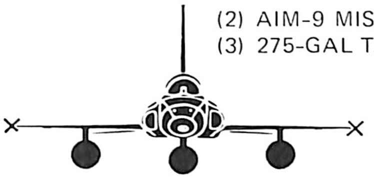
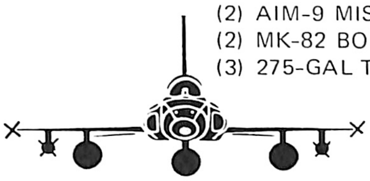
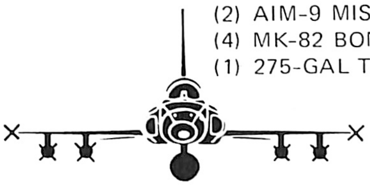
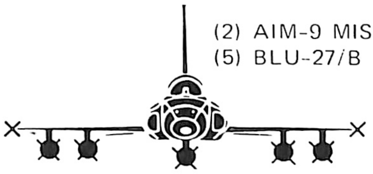
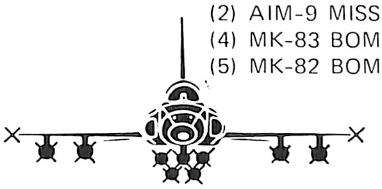
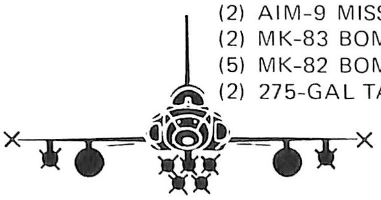


FIGURE B-23. F-5E TROPICAL ATMOSPHERE SPECIFIC POWER VS TURN RATE – MACH 0.8

| CONFIGURATION | LOADING | WEIGHT (90% FUEL) (LB) | RATE OF* CLIMB (FPM) |
|---|---|---|---|
| INTERCEPT (INTERNAL FUEL) |  (2) AIM-9 MISSILES | 15,192 | 4,120 |
| INTERCEPT OR COMBAT AIR PATROL (MAXIMUM FUEL) |  (2) AIM-9 MISSILES<br>(3) 275-GAL TANKS | 21,078 | 1,620 |
| INTERDICTION OR CLOSE AIR SUPPORT (MAXIMUM FUEL) (MK-82 BOMBS) |  (2) AIM-9 MISSILES<br>(2) MK-82 BOMBS<br>(3) 275-GAL TANKS | 22,396 | 950 |
| INTERDICTION OR CLOSE AIR SUPPORT (MAXIMUM FUEL) (MK-82 BOMBS) |  (2) AIM-9 MISSILES<br>(4) MK-82 BOMBS<br>(1) 275-GAL TANK | 19,808 | 1,910 |
| INTERDICTION OR CLOSE AIR SUPPORT (INTERNAL FUEL) |  (2) AIM-9 MISSILES<br>(5) BLU-27/B | 20,112 | 1,600 |
| CLOSE AIR SUPPORT (INTERNAL FUEL) (GROWTH) |  (2) AIM-9 MISSILES<br>(4) MK-83 BOMBS<br>(5) MK-82 BOMBS | 22,657 ⊛ | 530 |
| CLOSE AIR SUPPORT MAXIMUM WEIGHT (GROWTH) |  (2) AIM-9 MISSILES<br>(2) MK-83 BOMBS<br>(5) MK-82 BOMBS<br>(2) 275-GAL TANKS | 24,436 ⊛ | -20 |

*MAXIMUM POWER AT BEST CLIMB SPEED
SEA LEVEL GEAR UP

⊛ GROWTH LOADINGS

FIGURE B-24. F-5E TROPICAL ATMOSPHERE SINGLE-ENGINE CLIMB CAPABILITY WITH EXTERNAL STORES

| CONFIGURATION | WEIGHT (50% FUEL) (LB) | SEA LEVEL RATE OF CLIMB (FPM)* | CRUISE CEILING (FT) ⊛ | COMBAT CEILING (FT) * |
|---|---|---|---|---|
| RAILS | 13,092 | 5,140 | 17,250 | 40,900 |
| RAILS + (3) PYLONS | 13,506 | 4,440 | 13,600 | 36,200 |

* MAXIMUM POWER, BEST CLIMB SPEED ⊛ NORMAL POWER, SINGLE ENGINE

FIGURE B-25. F-5E TROPICAL ATMOSPHERE SINGLE-ENGINE CLIMB AND CEILING CAPABILITY WITHOUT EXTERNAL STORES

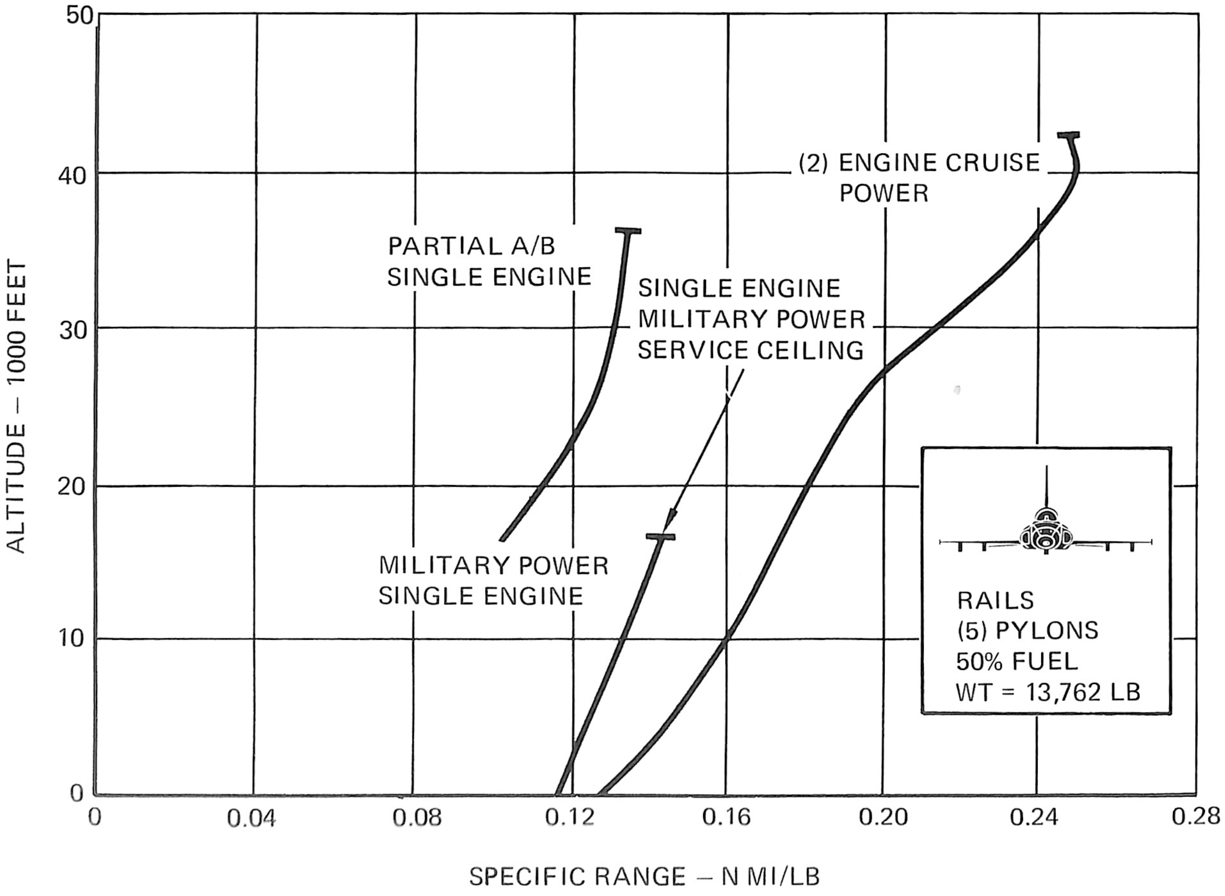


FIGURE B-26. F-5E EFFECT OF SINGLE ENGINE ON TROPICAL ATMOSPHERE CRUISE PERFORMANCE